This Environmental Impact Assessment and associated Baseline Reports were prepared for Cenovus FCCL Ltd. by Golder Associates Ltd. (Golder Associates) and Matrix Solutions Inc. as part of the Cenovus Phase H and Eastern Expansion Project. The following Golder personnel (unless affiliations otherwise indicated) were responsible for completing the assessments as well as writing and editing these documents:

Project Management
Anusa Sivalingam
David Blower
Cameron White
Kate Rogers
Ruchi Lakhani
Steven Strawson

Air Emissions Effects
Brian Gaas
Guy Eiserman
Zsolt Kovats

Air Quality
Dennis Chang
Mark Crummey
Rebekah Martin

CAD
Barry Wheeler
Deborah Maier
Ian Griffin

Conservation and Reclamation
Dale Doram
Lisa Kempenaar

Documentation
Corrina Ligertwood
Dana St. Louis
Jeff Miguel
Krista Freeman

Fish and Fish Habitat
Kristine Mason
Scott McKenzie

GIS
Guy Eiserman
Selena Shaw

Historical Resources
Brent Murphy
Rebecca Balcom
Vincent Balls

Hydrogeology
Gord MacMillan
(Matrix Solutions Inc.)
Soren Poschmann

Hydrology
Degefa Senbeta
Eri Ilich
Murray Fitch

Human and Wildlife Health Risk Assessment
Ann-Marie Norris
Arainn Atkinson
Audrey Wagenaar
Christine Thomas
Ryan Stevenson
Stephanie Ko
Thalia Zis

Noise
Tomasz Nowak
Victor Young
Virgini Senden

Resource Use
Haukur Bjornsson
Jesse O'Brien

Socio-Economics
Bethany Beale
Haukur Bjornsson
Linda Havers
Stephen Johnson
(SJ Research Services)

Terrestrial Resources
Amy Darling
Andrea Ortega
Bona Cortez
Brock Simons
Brandi Hall
Collen Middleton
Dale Doram
Ken McCarron
Kimberly Dawe
Marcie Plishka
Martin Jalkotzy
Ruth Ibemesim

Traditional Land Use
Mitchell Goodjohn
Rebecca Stuparyk

Visual Resources
Peter Thiede

Water Quality
Azim Ekram
Laura Pacholski
Zsolt Kovats

Application documents and CDs were reproduced and compiled by Little Rock Document Services.

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

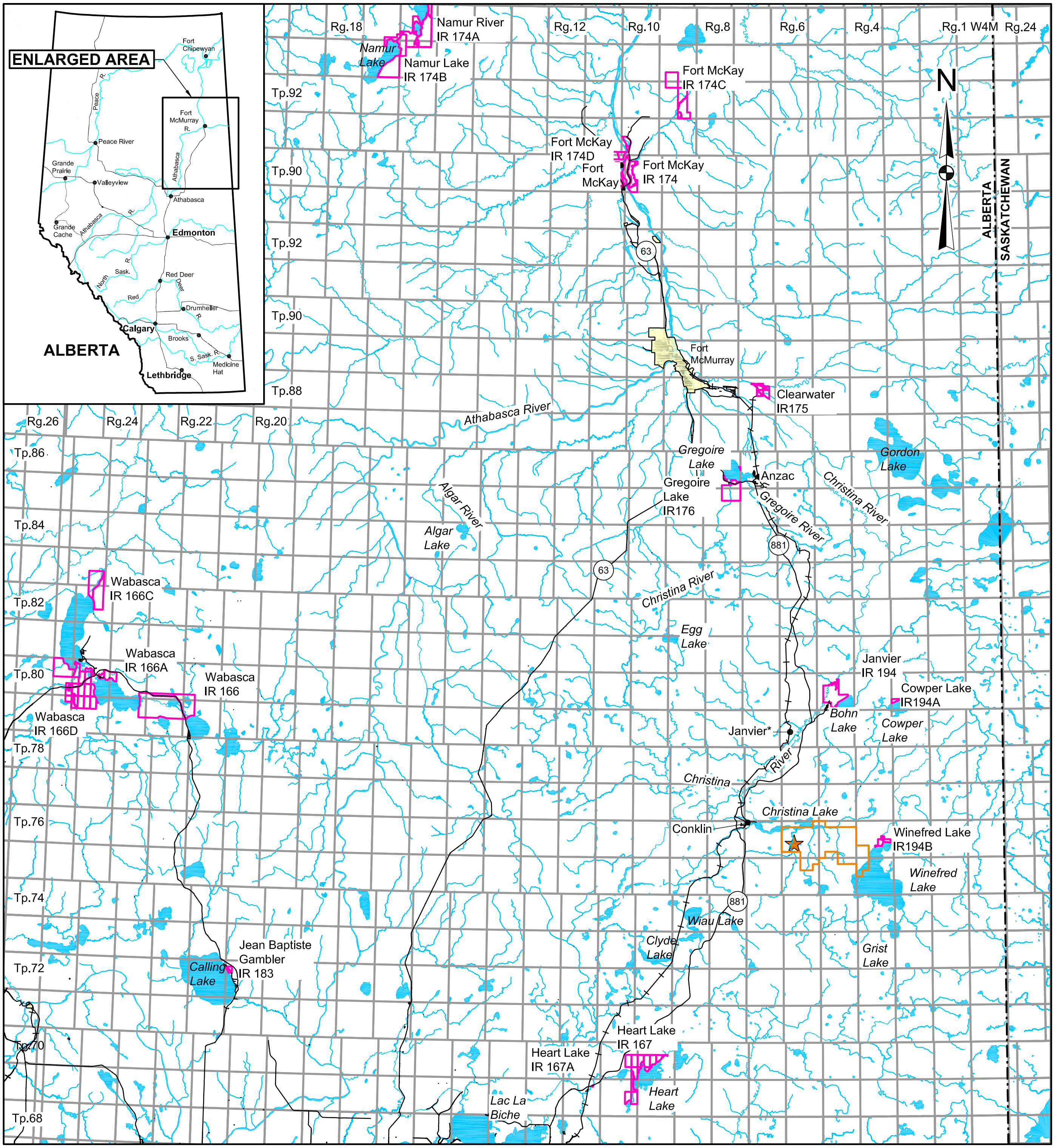
LIST OF APPENDICES

1 INTRODUCTION

Cenovus FCCL Ltd. (Cenovus) as operator for the Foster Creek-Christina Lake (FCCL) Partnership (Cenovus and ConocoPhillips) is developing and operating a commercial scheme to recover bitumen from the McMurray Formation at the Christina Lake Thermal Project (CLTP) located in Townships 75 and 76, Ranges 4, 5 and 6, West of the Fourth Meridian (W4M). This scheme, utilizing in-situ Steam Assisted Gravity Drainage (SAGD) well pairs and on-site facilities, operates under approvals issued by the Energy Resources Conservation Board (ERCB), Scheme No. 8591Y, and Alberta Environment and Sustainable Resource Development (ESRD), Approval No. 48522-01-03, as amended. The CLTP is located approximately 20 km southeast of the community of Conklin, Alberta. A regional map of the area surrounding CLTP is provided in Figure 1-1.

The original joint application and Environmental Impact Assessment (EIA) for the CLTP was submitted to the ERCB and ESRD in March 1998. In 2000, the CLTP scheme and the Alberta *Environmental Protection and Enhancement Act* (EPEA) application were approved by the ERCB and ESRD for production of 70,000 bbl/d (11,200 m^3/d) of bitumen. Through a series of amendments, the CLTP has been approved by the ERCB and ESRD for a cumulative production capacity of 238,800 bbl/d (37,966 m^3/d) with a total of 24 Once Through Steam Generators (OTSGs) and two Gas Turbine Generators/Heat Recovery Steam Generators (GTG/HRSGs) for Phases A to G.

In December 2012, Cenovus filed the CLTP Phases CDE Second Stage OTSGs application which proposes the addition of two second stage OTSGs to CLTP, increasing production capacity by 21,200 bbl/d (3,371 m^3/d) to 260,000 bbl/d (41,335 m^3/d). The equipment proposed in the CDE Second Stage OTSGs application is included in the EIA Baseline Case, as this creates a clearer and more transparent application. Cenovus is also anticipating approval of the Phases CDE Second Stage OTSGs application in 2013.



3 0 3

SCALE KILOMETRES

LEGEND

- COMMUNITY
- PHASE H CENTRAL PROCESSING FACILITY LOCATION
- HIGHWAY
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- LEASE AREA
- WATERBODY

NOTE

*LOCALLY KNOWN AS CHARD.

REFERENCE

BASE DATA OBTAINED FROM IHS ENERGY INC. AND DEPARTMENT OF NATURAL RESOURCES CANADA, ALL RIGHTS RESERVED.
DATUM: NAD27 PROJECTION: UTM ZONE 12

PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

CHRISTINA LAKE THERMAL PROJECT LOCATION OVERVIEW

Golder Associates

PROJECT	10.1346.0044.Vol3	
DESIGN	CW	07/03/2013
CADD	IPG	07/03/2013
CHECK	CW	14/03/2013
REVIEW	SNS	14/03/2013

FILE No. 1013460044Vol3A001
SCALE AS SHOWN REV. 0

FIGURE: 1-1

\\golder.gds\CAL\MCAD\2010\1346\10-1346-0044\VOL_3\Report_A\Fig1-1_1013460044Vol3A001ProjLoc.dwg Mar 19, 2013 - 4:59pm

The proposed CLTP Phase H and Eastern Expansion (the Project) involves addition of a new phase of steam generation, water treating and oil treating equipment beyond previously approved Phases A to G, plus the eastward expansion of the current lease boundary. The Project supports a production capacity increase of 50,000 bbl/d (7,949 m^3/d) to 310,000 bbl/d (49,284 m^3/d).

The Project includes the following major equipment additions:

- five 93.8 MW Higher Heating Value (HHV) OTSGs (absorbed duty 77.2 MW);
- one 11.3 MW HHV glycol heater;
- one oil treating system (inlet degasser, Free Water Knockout (FWKO), two treaters);
- one produced water deoiling train (skim tank, Induced Gas Flotation [IGF] vessel, oil removal filters, oil recycle tank, deoiled water tank);
- one Warm Lime Softener (WLS) system;
- one Water Treatment (Strong Acid Cation [SAC]/Weak Acid Cation [WAC]) system; and
- one Vapour Recovery Unit (VRU) compressor package.

In addition to the Central Processing Facility (CPF) modifications, the Project includes 172 additional SAGD pads and 6 brackish pads. This brings the cumulative number of SAGD pads to 203 and brackish pads to 14. The number of disposal pads will remain unchanged at five.

2 TERMS OF REFERENCE

The Project's proposed Terms of Reference (TOR) for the EIA were submitted to ESRD in July 2012. In November 2012, ESRD issued the final TOR for the Project (ESRD 2012). A copy of the final TOR is provided in Appendix 2-I.

This assessment was completed to meet the relevant TOR (ESRD 2012) for the Project (Appendix 2-I). The TOR also includes the requirements of the *Canadian Environmental Assessment Act, 2012* (Government of Canada 2012) and other applicable federal legislation. Volume 1 provides additional detailed *Environmental Protection and Enhancement Act* information requirements. Concordance tables have been provided in Appendix 2-II.

3 ASSESSMENT APPROACH

To gain approval for this development, Cenovus has developed an integrated application to the ERCB and ESRD for the Project. This integrated application provides details on the Project and provides supporting information for additional approvals for the Project. The integrated application and EIA have also been completed to conform to the requirements of applicable legislation.

3.1 IMPACT ASSESSMENT OVERVIEW

As required in the TOR for the Project (ESRD 2012), the EIA examines the potential environmental and socio-economic effects of the Project. Based on the implementation of mitigation measures and Cenovus's plans to manage impacts, residual effects were assessed.

Information on Cenovus's 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, and 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;
- data collected for previous regulatory applications including the original 1998 CLTP Application (PanCanadian 1998), and the Phases 1E, 1F, and 1G Expansion Application (EnCana 2009);
- digital elevation data for the study area (from National Topographic Database);
- government resource agencies, such as ESRD;

- government statistics;
- 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;
- available Traditional Land Use information; and
- Alberta Vegetation Inventory data supplied by Alberta Pacific Forest Industries Inc.

Existing regional data were also used for the initial Project design work. Cenovus 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 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:
  - Introduction;
  - Public Consultation;
  - Project Layout;
  - Geology and Geophysics;
  - Reservoir and Recovery Process;
  - Drilling and Completions;
  - Facilities;
  - Groundwater Management;
  - Environmental and Safety Management;

  - Land;
  - Alternatives Considered;
  - Regional Co-Operation;
  - Summary of the EIA;
  - Conservation and Reclamation Plan; and
  - EPEA Application.
- Volume 2 includes:
  - Introduction to the EIA;
  - Assessment Approach
  - EIA Assessment Methods;
  - Terms of Reference (Appendix 2-I);
  - Concordance Tables (Appendix 2-II)
  - Common and Scientific Names (Appendix 2-III);
  - Quality Assurance and Quality Control (Appendix 2-IV);
  - Climate Change Considerations (Appendix 2-V); and
  - Monitoring Programs (Appendix 2-VI).
- Volumes 3 includes:
  - Air Quality Assessment;
  - Noise Assessment;
  - Environmental Health Risk Assessment (including human and wildlife health risk assessments); and
  - Air Emissions Effects Assessment.
- Volume 4 includes:
  - Hydrogeology Assessment;
  - Hydrology Assessment;
  - Water Quality Assessment; and
  - Fish and Fish Habitat Assessment.
- Volume 5 includes:
  - Terrain and Soils Assessment;
  - Terrestrial Vegetation, Wetlands and Forest Resources Assessment;
  - Wildlife and Wildlife Habitat Assessment; and

  - Biodiversity Assessment.
- Volume 6 includes:
  - Traditional Land Use Assessment;
  - Resource Use Assessment;
  - Visual Resources Assessment;
  - Historic Resources Assessment; and
  - Socio-Economic Assessment.
- 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 (ESRD 2012) and provides additional information to address federal regulations.

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, 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;
- Traditional Knowledge that has been gathered specifically for the CLTP;
- Traditional Knowledge from public documents;
- Information about 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 about 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, including 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;
- 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 Assessment Cases

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 Cumulative Effects Assessment (CEA) for the Project.

The PDC includes the Application Case developments plus other regionally planned developments announced up to six months prior to the filing of this Application. The methodology for completing this case is the same as for the Application Case. 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 because the planned developments 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 developments is based on what was publicly available on September 30, 2012. Projects disclosed after that date, or projects where approvals were issued or plans were modified after September 2012 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, because they consider the effects of existing and approved developments in combination with the Project and in combination with other planned developments. 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 2010). 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 identifies key issues and questions for the Project and addresses them to frame the relationship between the Project and potential environmental effects. 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 Lower Athabasca Regional Plan (LARP, Government of Alberta 2012), 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 the Regional Sustainable Development Strategy (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 (Volumes 3 to 6).

4.2.1.1 Facilities Location

The location of facilities and infrastructure relative to Christina and Winefred lakes 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 (CEAA 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 Volume 2, 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 the 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°C to +35°C.

Historic changes in temperature and precipitation, as well as the possible changes in the future were evaluated for the Project (Volume 2, 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 for air quality and noise include the following:

- emissions 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 for aquatic resources 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 for terrestrial resources 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 for traditional land use include the following:

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

1.1.1.1 Resource Use

Key issues for resource use include the following:

- aggregate resources;
- berry picking;
- environmentally important areas;
- fishing;

- forestry;
- hunting and trapping; and
- recreation.

4.2.1.7 Socio-Economic

Key issues for socio-economics 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 TOR for the Project 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, additional issues 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 developments. Therefore, if the Application Case resulted in the determination that the Project had a negligible residual effect, the assessment under the PDC was not completed because the effects of the Project are not expected to overlap with those of future planned developments.

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

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

Number	Key Question
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?

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

Number	Key Question
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 existing and approved developments and the Project have on noise levels?
Human Health	
HHAC-1	What effects could emissions from existing and approved developments and the Project have on short-term (acute) exposure and human health?
HHAC-2	What effects could emissions from existing and approved developments and the Project have on long-term (chronic) exposure and human health?
HHAC-3	What effects could PM2.5 emissions from existing and approved developments and the Project have on human health?
Air Emissions Effects	
AEEAC-1	What effects could air emissions from existing and approved developments and the Project have on surface waters?
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?
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?
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 and fish habitat fragmentation?
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 forest resources?
TRAC-3	What effects could existing and approved developments and the Project have on wildlife abundance, habitat and movement?
TRAC-4	What effects could existing and approved developments, the Project and planned developments have on the species, ecosystem and landscape levels of biodiversity?

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

Number	Key Question
Wildlife Health	
WHAC-1	What effects could emissions from existing and approved developments and the Project have on long-term wildlife health?
Socio-Economic	
SEAC-1	What effects could existing and approved developments and the Project have on the local and provincial economies?
SEAC-2	What effects could existing and approved developments and the Project have on population, housing, services, traffic and infrastructure?
Traditional Land Use	
TLUAC-1	What effects could existing and approved developments and the Project have on traditional land uses?
Historic Resources	
HRAC-1	What effects could existing and approved developments and the Project have on historic 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?
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 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 short-term (acute) exposure and human health?
HHPDC-2	What effects could emissions from existing and approved developments, the Project and planned developments have on long-term (chronic) exposure and human health?
HHPDC-3	What effects could $PM_{2.5}$ emissions from existing and approved developments, the Project and planned developments have on human health?
Air Emissions Effects	
AEEPDC-1	What effects could air emissions from existing and approved developments, the Project and planned developments have on surface waters?
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?
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 and fish habitat fragmentation?
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 forest resources?
TRPDC-3	What effects could existing and approved developments, the Project and planned developments have on wildlife abundance, habitat and movement?
TRPDC-4	What effects could existing and approved developments, the Project and planned developments have on the species, ecosystem and landscape levels of biodiversity?
Wildlife Health	

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

Number	Key Question
WHPDC-1	What effects could emissions from existing and approved developments, the Project and planned developments have on long-term wildlife health?
Historic Resources	
HRPDC-1	What effects could existing and approved developments, the Project and planned developments have on historic resources?
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?
Visual Resources	
VRPDC-1	What effects could existing and approved developments, the Project and planned developments have on visual resources?

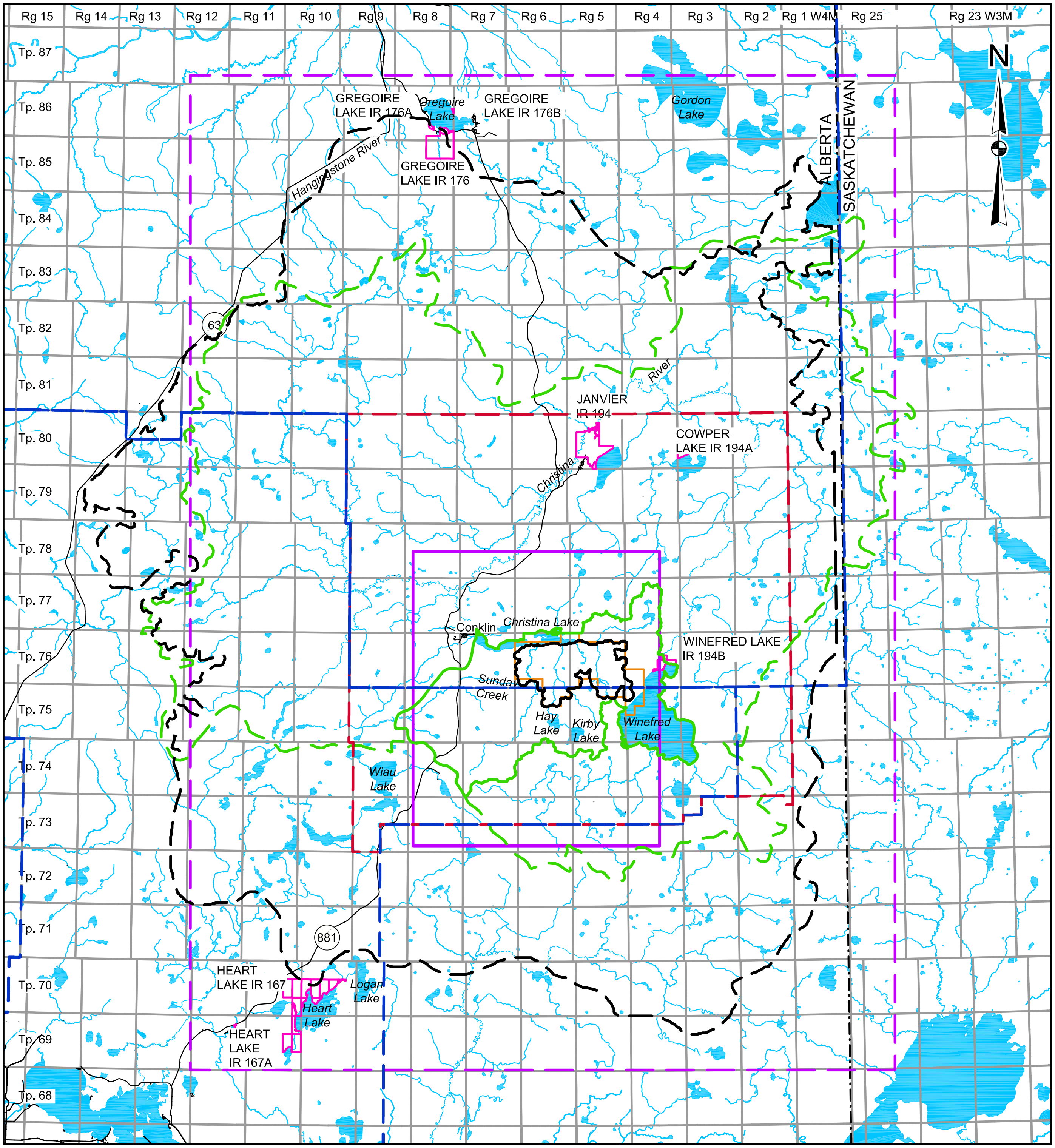
4.3 SPATIAL CONSIDERATIONS

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 or indirectly affected by the Project. 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 air quality assessment and dispersion modelling processes, the spatial extent of the effects of the Project on ambient air quality determines the region over which modelling is conducted. Four spatial areas were considered in the assessment and 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 is a 392 km by 564 km area that extends north of the Athabasca region, south of Cold Lake, east into Saskatchewan, and west to Ranges 22 and 23 W4M. It is large enough to encompass the effects related to air emissions from the oil sands developments in the Athabasca and Cold Lake regions. The modelling domain also includes key communities in Alberta and Saskatchewan.
- The **Air Quality Regional Study Area (RSA)** defines the region over which the dispersion modelling results are presented and is smaller than the modelling domain. The RSA was sized to meet the requirements of the Project TOR (Volume 2, Section 2). The RSA is defined by a 125 km by 176.5 km area as shown in Figure 4.3-1. It is large enough to capture the air quality effects associated with the Project. The RSA extends into the province of Saskatchewan to capture potential transboundary air quality effects near the Alberta/Saskatchewan border.
- The **Air Quality Local Study Area (LSA)** defines the area in the immediate vicinity of the Project where the majority of air quality effects associated with the Project 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 ESRD *Air Quality Model Guideline* requirements for study areas (AENV 2009). The LSA, as shown in Figure 4.3-1, is defined by an area of 45 km by 55 km, encompassing the Project footprint.



LEGEND

- COMMUNITY
- RAILWAY
- WATERCOURSE
- AIR LOCAL STUDY AREA
- AQUATIC RESOURCES LOCAL STUDY AREA
- NOISE LOCAL STUDY AREA
- TRADITIONAL LAND USE LOCAL STUDY AREA
- AIR REGIONAL STUDY AREA
- AQUATICS RESOURCES REGIONAL STUDY AREA
- RESOURCE USE REGIONAL STUDY AREA
- SOCIO-ECONOMIC REGIONAL STUDY AREA
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- TRADITIONAL LAND USE REGIONAL STUDY AREA
- WATERBODY

25 0 25
SCALE KILOMETRES

REFERENCE

BASE DATA FROM IHS ENERGY INC. DATUM: NAD83 PROJECTION: UTM ZONE 12

PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL EXPANSION
PHASE H AND EASTERN EXPANSION

TITLE

LOCAL AND REGIONAL STUDY AREAS

Golder Associates

PROJECT	10.1346.0044.VOL2		FILE No. _1013460044VOL3A00	
DESIGN	CW	03/19/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	03/19/2013	FIGURE: 4.3-1	
CHECK	CW	03/19/2013		
REVIEW	SS	03/19/2013		

L:\2010\1346\10-1346-0044\VOL_2\Report_A\Fig4.3-1_1013460044VOL3A003Study_Areas.dwg Mar 21, 2013 - 8:58am

- The **plant** in the air quality assessment refers to the Cenovus Christina Lake Thermal Project's CPF. The plant boundary is shown in Figure 4.3-1. Compliance with Alberta Ambient Air Quality Objectives (AAAQOs) is required outside the plant boundary.

Ground-level concentrations were predicted by the dispersion model at selected locations within the modelling domain. The selection of these locations (referred to as receptors), was based primarily on the ESRD *Air Quality Model Guideline* (AENV 2009), which recommends the following receptor placement:

- spacing of 50 m within 1 km of the sources of interest;
- spacing of 250 m within 2 km of the sources of interest;
- spacing of 500 m within 5 km of the sources of interest; and
- spacing of 1,000 m between 5 and 10 km from the sources of interest.

In addition to the receptors placed near the Project, the air quality assessment included additional receptors distributed across the modelling domain, spaced at either 3-km, 6-km or 15-km intervals. Receptors were also placed every 20 m along the CLTP plant boundary. The receptors are detailed further in Volume 3, Appendix 3-III, Section 4.3.

One of the goals of the air quality assessment is to identify locations that are important to regional stakeholders and evaluate the air quality effects at these locations. To facilitate this, maximum air quality concentrations were predicted for each of the receptors indicated in Table 4.3-1. The list includes 3 communities, 4 Aboriginal communities, 2 recreation areas, 18 cabins and the CLTP on-site worker camp. These receptors represent the primary population centres that could potentially experience increased ground-level concentrations due to the Project.

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

Receptors	Location[(a)]	
	Distance [km]	Direction
Aboriginal Communities		
Janvier (IR 194)	38.3	NNE
Winefred Lake (IR 194B)	22.8	E
Heart Lake (IR 167)	79.7	SSW
Peter Pond (IR 193), SK	125.7	ENE
Communities		
Conklin	13.7	WNW
Lac La Biche	114.1	SW
Cold Lake	132.2	SSE
Recreation Areas		
Fishing Camp (Christina Lake)	7.9	NE
Campground (Christina Lake)	11.5	WNW
Cabins[(b)]		
Cabin A	10.3	ENE
Cabin B	7.3	NE
Cabin C	8.7	NE
Cabin D	9.0	ENE
Cabin E	5.9	S
Cabin F	3.4	SSW
Cabin G	13.0	SSE
Cabin H	10.5	SSE
Cabin I	9.7	SSE
Cabin J	4.1	SW
Cabin K	3.4	SW
Cabin L	10.6	WNW
Cabin M	17.2	NW
Cabin N	19.5	NW
Cabin O	4.8	E
Cabin P	3.7	N
Cabin Q	15.2	SE
On-Site Worker Camp	1.1	SSW
Maximum Plant Boundary	–	–

(a) Distance and direction are relative to the approximate centre of the CLTP Plant.

– = Maximum plant boundary receptors are spaced 20 m apart along the CLTP plant boundary.

4.3.2 Noise

Noise levels for the Project were determined over a Noise LSA. The LSA is defined by a 42 by 45 km rectangle that is centred on the Project, and was chosen to encompass potential noise effects of the Project, noise-sensitive receptors and the ERCB 1.5 km criteria boundary. In addition, the Project noise contributions were assessed over a 23 by 39 km rectangular area centred on the Project, to allow for assessment of noise emissions from CLTP (including the Project) in isolation (i.e., excluding the contribution of Cenovus Narrows Lake and third-party facilities). Assessment of CLTP in isolation is not required by Directive 038 (EUB 2007), but was included to account for the atypical situation in which CLTP is effectively surrounded by other facilities in such a way that the ERCB 1.5 km criteria boundary is located at a very large distance from the Project itself.

According to the ERCB, noise-sensitive receptors are considered to be any permanent residences or seasonally occupied dwellings used at least six weeks out of the year that are outside the Lease Area and may be affected by the Project. In the absence of any such dwellings, the ERCB indicates that noise should be assessed at unoccupied locations 1.5 km from the Lease Area (i.e., along the so-called ERCB 1.5 km criteria boundary). Where ERCB 1.5 km criteria boundaries from multiple facilities overlap, the accepted approach is to create a single ERCB 1.5 km criteria boundary by merging the individual ERCB 1.5 km criteria boundaries.

The Project is located in an area with a high density of energy-related developments. The Lease Area of the Project is abutted by the Lease Areas of Cenovus Narrows Lake, MEG Energy Christina Lake Regional Project, Devon Jackfish 1, 2 and 3, and Harvest Operations BlackGold in such a way that CLTP is effectively surrounded. As a result, it was necessary to define a single 1.5 km ERCB criteria boundary surrounding all facilities for assessment of cumulative noise levels in the Baseline Case, Application Case, and PDC. Four receptors located along the ERCB 1.5 km criteria boundary were selected for this assessment (Noise Receptors R1, R2, R3 and R4). These receptors are located in roughly the four cardinal directions and were selected based on the highest predicted noise level in each of these directions. Two receptors, Conklin and Christina Lake Lodge, were considered for consistency with previous assessments and because these two receptors are located within the 1.5 km ERCB criteria boundary. Four additional receptors located along the shore line of Winefred Lake (Noise Receptors R5, R6, R7 and R8) were added to characterize noise in the area of the planned Winefred Lake Provincial Recreation Area, as part of a requirement outlined in the TOR.

In accordance with Directive 038 and the TOR, three receptors were also selected along a 1.5 km buffer around the CLTP Lease Area. These receptors were included for consistency with previous noise assessments of the CLTP and will be used to characterize the noise effects of the CLTP (including the Project) in isolation (i.e., ignoring the contributions from Cenovus Narrows Lake and the third-party facilities). Although the inclusion of these receptors is not required by Directive 038, given the atypical situation (i.e., the CLTP being effectively surrounded by other facilities) and the resulting large distances between the Directive 038 receptors and the CLTP itself, their inclusion is worthwhile.

The noise receptor locations and additional details are provided in Table 4.3-2.

Table 4.3-2 Noise Receptor Locations

Noise Receptor	Description/Comments	UTM Coordinates [NAD83, Zone 12]		Approximate Distance from the CLTP Central Processing Plant [km]
		Easting [m]	Northing [m]	
Christina Lake Lodge	Recreational area used for fishing and as a worker camp for oil and gas employees	497993	6165154	10.8
Conklin	Small town	494653	6164843	13.7
R1	Unoccupied location on ERCB 1.5 km criteria boundary south of Devon Lease Area	506285	6149454	10.3
R2	Unoccupied location on ERCB 1.5 km criteria boundary west of Harvest Operations Lease Area	497556	6157541	10.0
R3	Unoccupied location on ERCB 1.5 km criteria boundary north of Cenovus Narrows Lake Lease Area	501566	6171863	13.5
R4	Unoccupied location on ERCB 1.5 km criteria boundary east of the CLTP Approved Area and south of the Eastern Expansion Area	522061	6152645	16.4
R5	Most affected location within proposed Winefred Lake Provincial Recreation Area	525091	6153677	18.8
R6	Possible cabin within proposed Winefred Lake Provincial Recreation Area	529587	6159017	22.3
R7	Possible cabin within proposed Winefred Lake Provincial Recreation Area	528815	6158908	21.5
R8	Possible cabin within proposed Winefred Lake Provincial Recreation Area	528562	6158754	21.3
1.5 km Project Boundary; S	Unoccupied location 1.5 km south of the CLTP Lease Area; used for assessment of the CLTP noise effects in isolation from other facilities	507340	6155917	3.8
1.5 km Project Boundary; W	Unoccupied location 1.5 km west of the CLTP Lease Area; used for assessment of the CLTP noise effects in isolation from other facilities	502445	6159947	4.9
1.5 km Project Boundary; N	Unoccupied location 1.5 km north of the CLTP Lease Area; used for assessment of the CLTP noise effects in isolation from other facilities	506074	6165387	5.8

Note: Locations based on datum NAD83 and coordinate system UTM Zone 12.

A Noise Regional Study Area (RSA) is not defined for the Noise Assessment. Because noise attenuates with distance, noise is considered to be a local effect. In the area beyond the LSA, noise emissions from the Project will attenuate to a level well below the ambient sound level resulting in negligible contributions from the Project.

4.3.3 Human Health

Effects to human health were evaluated on a regional basis, which was based on the two study areas defined by the Air Quality Assessment: the LSA and RSA (Figure 4.3-1). Receptors were selected from within the LSA and RSA and were evaluated for acute and chronic effects. The Air Quality RSA for the Human Health Risk Assessment includes the Regional Municipality of Wood Buffalo, Alberta; however, communities in Lac La Biche County, the District of Bonnyville, and the Peter Pond area (Saskatchewan) were also included, which lie outside of the RSA. Seventeen hunter/trapper cabin locations were considered in the assessment.

4.3.4 Air Emissions Effects

Two different study areas were used in the Air Emissions Effects (AEE) assessment based on whether the environmental effects of emissions occur while emitted compounds are suspended in the air or after deposition (Figure 4.3-1). The AEE Suspended Matter Study Area was defined as the intersection of the Terrestrial Resources RSA and the Air Quality RSA. The AEE Suspended Matter Study Area encompasses the area where the potential fumigation of terrestrial resources is assessed.

The AEE Deposited Matter Study Area was based on the contour where the change in acid deposition per 100 m under the PDC was 0.01 keq H^+/ha/y, which marks the precision limit of the air deposition model to identify differences in acid deposition to adjacent receptors. By limiting the AEE Deposited Matter Study Area to the 0.01 keq H^+/ha/y per 100 m acid deposition boundary, the assessment will not be biased by including receptors located far from emissions. The PDC includes all of the known potential emission sources, so the size and shape of the AEE Deposited Matter Study Area captures the emissions sources potentially contributing to cumulative effects. The assessments of acidification, metal and Polycyclic Aromatic Hydrocarbons (PAH) deposition, and eutrophication were evaluated in the AEE Deposited Matter Study Area.

During the winter months, most small waterbodies and watercourses in northern Alberta experience large increases in base cation concentrations from ice exclusion (“freeze-out”) as well as decreased sulphate concentration as a result of the chemical reduction of sulphate to sulphide. Water chemistry data from winter months (November to March) were not included in the aquatic acidification assessment to avoid biasing the results based on high winter alkalinities. No other temporal restrictions were placed on base cation, acid anion, pH, dissolved organic carbon, or total alkalinity data. All of the waterbodies located in the AEE Deposited Matter Study Area with available non-winter base cation concentration data were included in the analysis.

Concentrations of metals and PAHs measured in surface waters before 2000 may have unsuitably high detection limits for a sensitive analysis of potential effects from atmospheric deposition. To avoid skewing results by a prevalence of concentrations reported as below detection limits, metals and PAH data from before 2000 were excluded from analysis.

4.3.5 Aquatic Resources

The same Aquatic Resources RSA and LSA were used for the Hydrology, Water Quality, and Fish and Fish Habitat components (Figure 4.3-1).

The Hydrogeology RSA and LSA are larger than the corresponding Aquatic Resources study areas (Figure 4.3-1). The Hydrogeology RSA was based on interpreted regional geology and groundwater flow patterns. The Hydrogeology RSA was selected to be of adequate areal extent to simulate cumulative effects of groundwater withdrawal and wastewater disposal in the vicinity of the Project. The Hydrogeology LSA was selected to be of adequate areal extent to encompass local effects of Project groundwater withdrawal and wastewater disposal and potential effects to groundwater quality. The Hydrogeology LSA also coincides with an area in which detailed geologic mapping was conducted.

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 likely 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 watershed (effective drainage area of 4,270 km^2 at the confluence with Christina River): The Winefred River originates from Grist Lake, and drains north before discharging to the Christina River about 40 km northwest of the Lease Area.

- Winefred Lake (surface area of 127 km^2 and effective drainage area 1,205 km^2): Inflows originate from Grist Lake and other small tributaries flowing from the south and west. Winefred Lake discharges to the Winefred River, which flows to the northeast.
- Christina River watershed upstream from its confluence with 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 Conklin and discharging into the Clearwater River about 110 km north of the Project site.
- Christina Lake (surface area of 21.3 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.
- Pony Creek and Kettle River watersheds (effective drainage area of 810 km^2): Pony Creek and the Kettle River are tributaries that flow southeast and enter the Christina River at about 25 km and 40 km north of the Project site, respectively.

The total area of the Aquatic Resources RSA is about 9,900 km^2. Most of the Aquatic Resources RSA lies within Alberta, with 2% extending into Saskatchewan. The portion in Saskatchewan lies within the Winefred River watershed. Most of the potential effects on aquatic resources are expected to be limited to the Christina Lake sub-basin (effective drainage area of 1,270 km^2) in the Christina River watershed.

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 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 extent of the Aquatic Resources LSA was defined using the 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 boundary was delineated mostly in consideration of the watershed boundaries of waterbodies and watercourses that may be directly or indirectly affected by the Project (Figure 4.3-1). The Aquatic Resources LSA occasionally crosses watershed boundaries. Where this occurs, 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 has a total drainage area of 986 km^2 and consists of five sub-basins, three of which drain into Christina Lake from the north (Figure 4.3-1). The sub-basins in the LSA include the following:

- Christina Lake sub-basin (drainage area of 58.6 km^2), including the lake surface area but excluding the drainage area south of the lake;
- Sawbones Creek sub-basin (drainage area of 122 km^2) draining into Christina Lake;
- Unnamed Watercourse 16 sub-basin (drainage area of 65.5 km^2) draining into Christina Lake;
- Unnamed Watercourse 6A sub-basin (drainage area of 29.1 km^2) draining into Christina River; and
- Jackfish River sub-basin (drainage area of 33.5 km^2) draining into Christina River.

The Aquatic Resources LSA is entirely within the Aquatic Resources RSA. The Aquatic Resources LSA has undulating terrain with extensive low-lying wetlands areas. The maximum elevation difference in the Aquatic Resources LSA is about 71 m, ranging from 554 metres above sea level (masl) at Christina Lake to 625 masl in the Sawbones Creek sub-basin. The average elevation of the Aquatic Resources LSA is about 560 masl.

Within the Aquatic Resources LSA, there are several small streams and small lakes that could be seasonally navigated by a canoe or small boat, though navigation on the streams in the Lease Area would either be impossible or impeded by low flows, debris, and in many locations by beaver dams. Other than Christina Lake and Winefred Lake, the watercourses and lakes within the Aquatic Resources LSA are not believed to be navigated regularly, if at all.

Hydrogeology

The Hydrogeology LSA is comprised of a square boundary extending from Townships 74 to 79, Ranges 3 to 8 W4M. The extent of the Hydrogeology LSA is shown in Figure 4.3-1 and is defined by the following:

- north - Township 79 bounded by Ranges 3 to 8 W4M, from the Stony Mountain Uplands near Waddell Creek in the northwest to near Cowper Lake in the northeast;
- east - Range 3 W4M bounded by Townships 74 to 79, from near Cowper Lake in the northeast to the Mostoos Hills Upland south of Winefred Lake in the southeast;
- south - Township 74 bounded by Ranges 3 to 8 W4M, located within the Mostoos Hills Upland; and
- west - Range 8 W4M bounded by Townships 74 to 79 from the Mostoos Hills Upland near Wiau Lake in the southwest to the Stony Mountain Uplands near Waddell Creek in the northwest.

The Hydrogeology LSA is also coincident with an area in which detailed geologic mapping was conducted.

4.3.6 Terrestrial Resources

4.3.6.1 Regional Study Area

The RSA was established to assess the contributions of the Project and other developments from a broader geographical context (Figure 1-2). 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., Cold Lake and East Side of the Athabasca [ESAR] Caribou Ranges);

- 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 RSA landforms and regional vegetation are discussed in detail in Volume 5 Appendix 5- II (Section 1.2.1).

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). The LSA covers an area of 16,352 ha and falls completely within the Central Mixedwood Natural Subregion (NRC 2006). This LSA incorporates all Project facilities and infrastructure (Project footprint) with a buffer of 500 m around these components. The buffer was applied to the Project footprint and follows the shoreline of Christina Lake (along the north boundary) intersected by the Lease Area.

The buffer represents a zone in which potential indirect effects of the Project may occur. Examples of indirect effects include air emissions on soils and vegetation, dust on vegetation, sensory disturbance to wildlife and surface water hydrology, all of which can have an effect on biodiversity in the area. Water use from surface water sources and shallow groundwater, may alter soil moisture regimes, shift vegetation community conditions and wildlife species assemblages, which may result in changes to biodiversity.

The Project includes disturbances in the CLTP approved area as well as the Eastern Expansion area. As a result, there is a 46.5 km^2 increase in the LSA from that reported in the terrestrial baseline reports for the Eastern Expansion area.

The LSA is situated in the Mostoos Hills Upland Section of the Eastern Alberta Plains Region (Andriashek 2003) and is characterized as having generally subdued relief and nearly level to slightly hummocky topography on glaciofluvial over moraine surficial material. Elevations within the Eastern Alberta 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-economic study area (study area) is defined as the area in which it is reasonable to expect communities to experience measurable socio-economic effects associated with the Project (e.g., increased employment opportunities and business growth, fiscal benefits, increased traffic and demand on social services). The study area includes the following communities:

- Regional Municipality of Wood Buffalo (including Janvier, Conklin, Fort McMurray and other communities);
- Lac La Biche County (including the Hamlet of Lac La Biche);
- Janvier Indian Reserve (IR) 194; and
- Heart Lake Indian Reserve (IR)167.

The closest communities to the Project include Conklin (15 km west of the Project), Janvier (also known locally as Chard [63 km]), and Janvier IR 194 (63 km north of the Project). The Project is 63 km northeast of the Lac La Biche County line (Figure 4.3-1).

4.3.8 Traditional Land Use

4.3.8.1 Local Registered Fur Management Areas and Local Study Area

The Traditional Land Use (TLU) LSA, Lease Area, and local Registered Fur Management Areas (RFMAs) are shown in Figure 4.3-1. The LSA partially overlaps RFMA #s 1595, 2316, 2322 and 2443. Of these, RFMA #2316 is registered to a Métis trapper and will be assessed in the TLU Assessment. The other directly affected RFMAs are held by non-Aboriginal trappers and are assessed in the Resource Use Assessment (Volume 6, Section 3).

4.3.8.2 Regional Study Area

The TLU 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. These areas may also include cabins and other areas of spiritual or historical importance based on oral tradition. The selection of the Terrestrial Resources RSA considers potential effects on wildlife and vegetation, which are important components of TLU activities. Details on the Terrestrial Resources RSA selection criteria are presented in Volume 5, Section 2.6.1. The potential effects of the Project on traditional fishing are also assessed within the context of the TLU RSA.

The TLU RSA represents the joint traditional use of a region and its resources by the members of nearby Aboriginal communities. Cenovus is engaged with the Chipewyan Prairie Dene First Nation (CPDFN), Fort McMurray First Nation (FMFN), Heart Lake First Nation (HLFN), Beaver Lake Cree Nation (BLCN), Cold Lake First Nation (CLFN), as well as Chard and Conklin Métis; and any TLU information arising from the engagement process will be provided when available.

4.3.9 Historic Resources

The effects on historic resources from the Project will occur directly within the proposed Project footprint development zones. The Project footprint required to effectively develop the resource will be dispersed across the Lease Area and will result in disturbance of a small portion of the total surface area.

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 RSA (Figure 4.3-1). The RSA covers an area of 1,641,023 ha or 176 townships surrounding the Project. It extends from a western boundary of Range 11 to the eastern edge of Range 1, 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. The RSA includes all or portions of 106 archaeological national registry (Borden) blocks identified in Alberta. The known distribution of historic resources and their landform associations within this area have been incorporated in a vegetation, hydrology and terrain-based predictive Geographic Information System (GIS) model that derives high, moderate and low historic resource potential areas. The model predictions are shown in Figure 4.3-1.

The LSA includes the areas that will be directly affected by construction activities as well as surrounding areas within the Lease Area. This includes all or portions of 31 sections of land over an area of approximately 8,029 ha including: Sections 19, 30 and 31 of 75-4 W4M; Sections 6 and 7 of 76-4 W4M; Sections 34 to 36 of 75-5 W4M; and Sections 1 to 3, 8 to 17 and 20 to 29 of 76-5 W4M. In addition to the LSA, Cenovus requested that a 500 m buffer be investigated along the southern boundary of the Lease Area. This buffer area includes portions of another eight sections of land including: Sections 24 to 28 and 33 of 75-5 W4M, and Sections 4 and 5 of 76-5 W4M. These additional sections were also addressed in the Historic Resources Impact Assessment (HRIA) completed for the Project.

The initial configuration of the areas to be examined during the field component was established by Cenovus and Alberta Culture in their review of the application for the permit to conduct these studies. After the Phase H HRIA report had been submitted and approved, Cenovus transferred four sections of land from the Winefred HRIA into the LSA for the Phase H Project. The sections that were added are: Sections 29 and 32 of 75-4 W4M, and Sections 5 and 8 of 76-4 W4M. All of these sections of land were assessed by the author under the Winefred HRIA (Balls 2012).

The sections of land affected by the Project footprint that are located within the Phases E, F and G LSA are discussed in the Phases E, F and G HRIA report (Blower 2007) and the EIA completed for these phases. Consideration is not given for these legal locations within this report as they are currently part of another application.

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

4.3.10 Resource Use

Two areas have been delineated to facilitate resource use 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 (i.e., the area within and surrounding the Project footprint). For this assessment, the Resource Use LSA has been determined to be the same boundary as the Terrestrial Resources LSA because effects to wildlife and vegetation are key considerations when assessing potential effects on resource use. In total, the LSA encompasses 16,352.1 ha and the RSA is 563,702.4 ha. The boundaries of the Resource Use RSA and LSA are shown in Figure 4.3-1.

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 footprint (Figure 4.3-1). Areas more than 20 km from the Project are likely to have poor views due to distance and atmospheric conditions with only the general form and outline of major features potentially discernible, even if a line-of-sight potentially exists (USDI 1986). No LSA was derived, since effects on visual resources cannot be assessed from the immediate vicinity of a development. The perceived effects would inevitably grow larger as viewpoints are placed in closer proximity to a development and the observed features would eventually dominate the view. Depending on the nature of the development, a minimum distance for viewpoints must be kept to allow for an assessment of the effects within the context of the existing landscape. The effects are therefore best assessed on a regional scale.

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 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. The general format of the linkage diagrams is illustrated in Figure 4.5-1. 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).

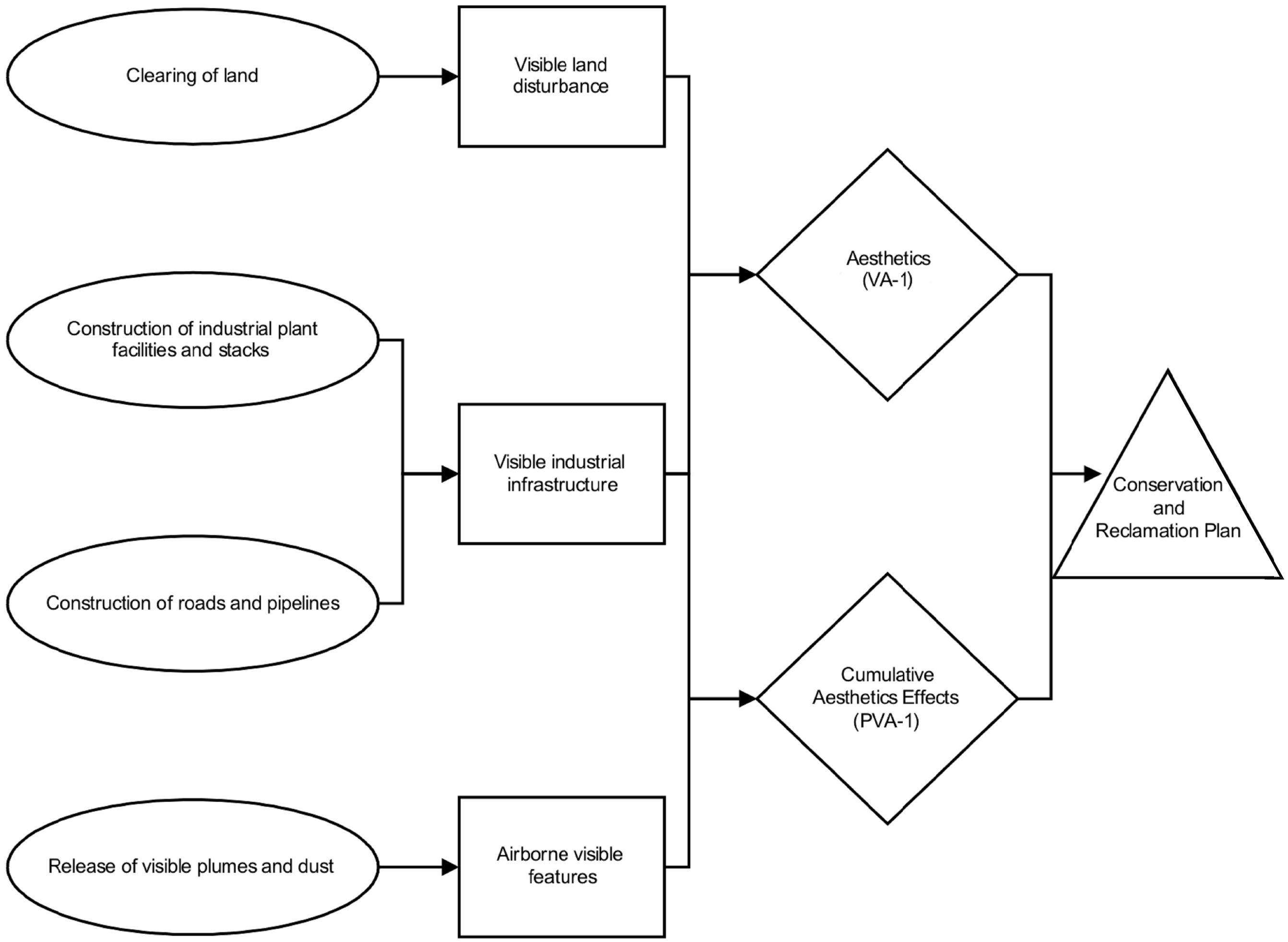
Linkage diagrams are used as tools to guide the impact analysis, which addresses each link on the diagram. They also show how the different environmental and social components are inter-related. The potential linkages between activities and impacts are evaluated to determine whether they apply to the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

L:\2010\1346\10-1346-0044\8900\Report_A\Fig4.5-1_10134600448900A001VisAesLink.dwg Mar 12, 2013 – 11:49am



PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

VISUAL RESOURCES LINKAGE DIAGRAM

Golder Associates

PROJECT	10.1346.0044.8900	
DESIGN	PT	07/01/2013
CADD	BSW	07/01/2013
CHECK	PT	12/03/2013
REVIEW	SNS	12/03/2013

FILE No.	10134600448900A001		
SCALE	AS SHOWN	REV.	0

FIGURE: 4.5-1

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 the following:

- 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).

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	Key Indicator Resources		Rationale
Aquatic Resources	**Waterbodies**		
	Christina Lake	Arctic grayling (sport fish) northern pike (sport fish) walleye (sport fish) white sucker (non-sport fish) brook stickleback (forage fish) benthic invertebrates	traditional resource, historical documentation, species with special status
	Winefred Lake	northern pike (sport fish) walleye (sport fish) white sucker (non-sport fish) spottail shiner (forage fish) benthic invertebrates	traditional resource, historical documentation
	Unnamed Waterbody (WB- 2)[d]	northern pike (sport fish) benthic invertebrates	captured during baseline sampling
	Unnamed Waterbodies (WB 12-04)[b]	northern pike (sport fish) brook stickleback (forage fish) benthic invertebrates	traditional resource and historical documentation
	Unnamed Waterbodies (WB-1, WB-2, WB-3, WB-4)[c]	benthic invertebrates	no historical documentation of captured fish species
	Unnamed Waterbodies (WB-5, WB-6)[c](WB 13-04)[b]	brook stickleback (forage fish) benthic invertebrates	historical documentation
	Watercourses		
	Sunday Creek[c]	Arctic grayling (sport fish) northern pike (sport fish) white sucker (non-sport fish) brook stickleback (forage fish) benthic invertebrates	traditional resource, historical documentation, species with special status
	Unnamed Watercourse (WC 3-07)[b]	longnose sucker (non-sport fish) brook stickleback (forage fish) benthic invertebrates	historical documentation
	Unnamed Watercourse (WC 4-07)[b]	northern pike (sport fish) brook stickleback (forage fish) benthic invertebrates	historical documentation
	Unnamed Watercourse (WC-3)[d]	brook stickleback (forage fish) benthic invertebrates	captured during baseline sampling
	Unnamed Watercourse (WC-4)[d], (UNT-5)[c], (WC-18)[e]	benthic invertebrates	no historical documentation of captured fish species
	Unnamed Tributaries(WC 6-04, 7-04, 8-04 and10-04)[b], (UNT-1, UNT-2, UNT-3 and UNT-4)[c]	white sucker (non-sport fish) brook stickleback (forage fish) benthic invertebrates	historical documentation

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

Resource	Key Indicator Resources	Rationale
Terrestrial Vegetation, Wetlands and Forest Resources	**Community Level**	
	riparian communities	highly productive areas with high rare plant potential; form important wildlife habitat and corridor areas
	peatlands (bogs and fens)	important boreal forest ecosystems for which reclamation is uncertain because of the complex interrelated hydrological, chemical and biotic conditions
	old growth forests	uncommon mature forest in the boreal forest with restricted distribution because of the fire regime
	productive forests	productive forests have economic importance
	rare and special plant communities	plant communities with restricted spatial distributions
	limited distribution land cover types	potentially unique land cover types covering <1% of the LSA
	Species Level	
	rare plant potential	plants with restricted spatial, ecological and temporal distributions
	traditional use plant potential	plants traditionally used by Aboriginal peoples for food, medicine or spiritual purposes
Wildlife	**Mammals**	
	woodland caribou	CEMA SEWG environmental indicator, provincial and federal status (*Species at Risk Act* [SARA] listed species - threatened), 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
	black bear	CEMA SEWG environmental indicator, traditional importance, recreational importance, ecological importance (carnivore)
	fisher	CEMA SEWG environmental indicator, provincial status – 'sensitive', ecological importance (carnivore), traditional and economic importance
	wolverine	federal status – 'special concern'
	myotis species (little brown myotis and northern myotis)	federal status – 'endangered'
	Birds	
	Canada warbler	member of the CEMA SEWG environmental indicator bird community - old growth forest birds, SARA listed 'threatened'

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

Resource	Key Indicator Resources	Rationale
	common nighthawk	SARA listed 'threatened'
	horned grebe	federal status – 'special concern'
	olive-sided flycatcher	member of the CEMA SEWG environmental indicator bird community - old growth forest birds, SARA listed 'threatened'
	rusty blackbird	riparian health indicator, SARA listed 'special concern'
	short-eared owl	federal status (SARA listed species – 'special concern')
	yellow rail	federal status (SARA listed species – 'special concern'), representative of the marsh bird community, riparian health indicator
	whooping crane	federal status – 'endangered'
	Amphibians	
	western (boreal) toad	provincial status – 'may be at risk', riparian health indicator, ecological importance, abundant information

(a) Waterbody and watercourse locations are shown in Volume 4, Appendix 4-VIII, Figure 2.
(b) Historical data from MEG (2005, 2008).
(c) Historical data from EnCana (2009).
(d) Data from 2011 field surveys for the Project (Volume 4, Appendix 4-VIII).
(e) Cenovus (2010).

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 affected 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.

The impact description criteria for each of the Project EIA components that determine an environmental consequence are detailed in Table 4.8-1. 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 Forest Resources	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
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

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 – 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: CPF not visible low: CPF visible from a small number of locations moderate: CPF visible from many locations high: CPF 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
Historic 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

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]
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. The screening system used to estimate an environmental consequence for residual impacts is shown in Table 4.8-2. 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

Cenovus 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.

Cenovus 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. Cenovus's current or planned monitoring activities are detailed in Volume 2, Appendix 2-VI.

5 PROJECTS CONSIDERED IN THE ASSESSMENT CASES

The assessment cases for the 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. An overview of the cases and the developments included in each assessment is provided in Table 5-1.

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. 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 and the Regional Aquatics Monitoring Program.

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 several possible developments to the effects predicted for the Project in combination with the existing and approved developments. For this EIA, a planned project is one that had been publicly disclosed up to six months prior to the submission of the Project application and EIA. Data used for the planned developments are based on the following:

- 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 Developments Included in the Assessment Cases

Status	Baseline Case	Application Case	Planned Development Case
Existing Cases	BlackPearl Resources Inc.	BlackPearl Resources Inc.	BlackPearl Resources Inc.
	Blackrod Pilot Project	Blackrod Pilot Project	Blackrod Pilot Project
	BP Terre de Grace Pilot SAGD	BP Terre de Grace Pilot SAGD	BP Terre de Grace Pilot SAGD
	Canadian Natural Resources Limited (Canadian Natural) Burnt Lake Pilot Project	Canadian Natural Resources Limited (Canadian Natural) Burnt Lake Pilot Project	Canadian Natural Resources Limited (Canadian Natural) Burnt Lake Pilot Project
	Canadian Natural Horizon Oil Sands Project	Canadian Natural Horizon Oil Sands Project	Canadian Natural Horizon Oil Sands Project
	Canadian Natural Kirby North In-Situ Project	Canadian Natural Kirby North In-Situ Project	Canadian Natural Kirby North In-Situ Project
	Canadian Natural Kirby South In-Situ Project	Canadian Natural Kirby South In-Situ Project	Canadian Natural Kirby South In-Situ Project
	Canadian Natural Primrose East In-Situ Project	Canadian Natural Primrose East In-Situ Project	Canadian Natural Primrose East In-Situ Project
	Canadian Natural Primrose North In-Situ Project	Canadian Natural Primrose North In-Situ Project	Canadian Natural Primrose North In-Situ Project
	Canadian Natural Primrose South In-Situ Project	Canadian Natural Primrose South In-Situ Project	Canadian Natural Primrose South In-Situ Project
	Canadian Natural Wold Lake In-Situ Project	Canadian Natural Wold Lake In-Situ Project	Canadian Natural Wold Lake In-Situ Project
	Cenovus Christina Lake Thermal Project Phases 1A to 1G	Cenovus Christina Lake Thermal Project Phases 1A to 1G	Cenovus Christina Lake Thermal Project Phases 1A to 1G
	Cenovus Foster Creek Thermal Project Phases 1A to 1H	Cenovus Foster Creek Thermal Project Phases 1A to 1H	Cenovus Foster Creek Thermal Project Phases 1A to 1H
	Cenovus Grand Rapid SAGD Pilot Project	Cenovus Grand Rapid SAGD Pilot Project	Cenovus Grand Rapid SAGD Pilot Project
	Cenovus Narrows Lake SAGD Project	Cenovus Narrows Lake SAGD Project	Cenovus Narrows Lake SAGD Project
	Connacher Algar Oil Sands Project	Connacher Algar Oil Sands Project	Connacher Algar Oil Sands Project
	Connacher Pod One Oil Sands Project	Connacher Pod One Oil Sands Project	Connacher Pod One Oil Sands Project
	Connacher Great Divide Oil Sands Project Expansion	Connacher Great Divide Oil Sands Project Expansion	Connacher Great Divide Oil Sands Project Expansion
	ConocoPhillips Canada (CPC) Surmont Commercial SAGD Project Phases 1 and 2	ConocoPhillips Canada (CPC) Surmont Commercial SAGD Project Phases 1 and 2	ConocoPhillips Canada (CPC) Surmont Commercial SAGD Project Phases 1 and 2
	Devon Jackfish SAGD Project	Devon Jackfish SAGD Project	Devon Jackfish SAGD Project
	Devon Jackfish 2 SAGD Project	Devon Jackfish 2 SAGD Project	Devon Jackfish 2 SAGD Project
	Devon Jackfish 3 SAGD Project	Devon Jackfish 3 SAGD Project	Devon Jackfish 3 SAGD Project
	Dover Operating Corp. Dover Pilot Project	Dover Operating Corp. Dover Pilot Project	Dover Operating Corp. Dover Pilot Project
	E-T Energy Poplar Creek In-Situ Pilot Project	E-T Energy Poplar Creek In-Situ Pilot Project	E-T Energy Poplar Creek In-Situ Pilot Project
	Grizzly Oil Sands Algar Lake SAGD Project	Grizzly Oil Sands Algar Lake SAGD Project	Grizzly Oil Sands Algar Lake SAGD Project
	Harvest Operation Corp. BlackGold Project Phase 1	Harvest Operation Corp. BlackGold Project Phase 1	Harvest Operation Corp. BlackGold Project Phase 1
	Husky Caribou Lake Thermal Demonstration Project	Husky Caribou Lake Thermal Demonstration Project	Husky Caribou Lake Thermal Demonstration Project

Table 5-1 Developments Included in the Assessment Cases (continued)

Status	Baseline Case	Application Case	Planned Development Case
Existing Cases (continued)	Husky McMullen Thermal Pilot Project	Husky McMullen Thermal Pilot Project	Husky McMullen Thermal Pilot Project
	Husky Sunrise Thermal Project	Husky Sunrise Thermal Project	Husky Sunrise Thermal Project
	Husky Tucker Thermal Project	Husky Tucker Thermal Project	Husky Tucker Thermal Project
	Imperial Oil Cold Lake In-Situ Project	Imperial Oil Cold Lake In-Situ Project	Imperial Oil Cold Lake In-Situ Project
	Imperial Oil Kearl Oil Sands Project	Imperial Oil Kearl Oil Sands Project	Imperial Oil Kearl Oil Sands Project
	JACOS Hangingstone Pilot and Commercial SAGD Project	JACOS Hangingstone Pilot and Commercial SAGD Project	JACOS Hangingstone Pilot and Commercial SAGD Project
	Japan Canada Oilsands Limited: Hangingstone Expansion	Japan Canada Oilsands Limited: Hangingstone Expansion	Japan Canada Oilsands Limited: Hangingstone Expansion
	Koch Germini Oil Sands Project	Koch Germini Oil Sands Project	Koch Germini Oil Sands Project
	Korea National Oil Corp: Black Gold Project	Korea National Oil Corp: Black Gold Project	Korea National Oil Corp: Black Gold Project
	Laricina Germain Commercial Demonstration Solvent-Cyclic SAGD Project	Laricina Germain Commercial Demonstration Solvent-Cyclic SAGD Project	Laricina Germain Commercial Demonstration Solvent-Cyclic SAGD Project
	Laricina Saleski Pilot	Laricina Saleski Pilot	Laricina Saleski Pilot
	MacKay Operating Corp. MacKay River Pilot and Commercial Project	MacKay Operating Corp. MacKay River Pilot and Commercial Project	MacKay Operating Corp. MacKay River Pilot and Commercial Project
	MEG Christina Lake Regional Project Phases 1 to 3	MEG Christina Lake Regional Project Phases 1 to 3	MEG Christina Lake Regional Project Phases 1 to 3
	Nexen Long Lake Commercial Project	Nexen Long Lake Commercial Project	Nexen Long Lake Commercial Project
	Nexen Long Lake South Project	Nexen Long Lake South Project	Nexen Long Lake South Project
	Pengrowth Lindberg Pilot	Pengrowth Lindberg Pilot	Pengrowth Lindberg Pilot
	Shell Grosmont Pilot	Shell Grosmont Pilot	Shell Grosmont Pilot
	Shell Jackpine Mine – Phase 1	Shell Jackpine Mine – Phase 1	Shell Jackpine Mine – Phase 1
	Shell Muskeg River Mine and Expansion	Shell Muskeg River Mine and Expansion	Shell Muskeg River Mine and Expansion
	Shell Orion EOR Project	Shell Orion EOR Project	Shell Orion EOR Project
	Southern Pacific McKay River Pilot Project	Southern Pacific McKay River Pilot Project	Southern Pacific McKay River Pilot Project
	Statoil AKSA Kai Kos Dehseh SAGD Project – Leismer Demo/Commercial	Statoil AKSA Kai Kos Dehseh SAGD Project – Leismer Demo/Commercial	Statoil AKSA Kai Kos Dehseh SAGD Project – Leismer Demo/Commercial
	Statoil AKSA Kai Kos Dehseh SAGD Project – Corner	Statoil AKSA Kai Kos Dehseh SAGD Project – Corner	Statoil AKSA Kai Kos Dehseh SAGD Project – Corner
	Suncor Dover SAGD Pilot and VAPEX Pilot	Suncor Dover SAGD Pilot and VAPEX Pilot	Suncor Dover SAGD Pilot and VAPEX Pilot
	Suncor Firebag Enhanced Thermal Solvent (ETS) Pilot Project	Suncor Firebag Enhanced Thermal Solvent (ETS) Pilot Project	Suncor Firebag Enhanced Thermal Solvent (ETS) Pilot Project
	Suncor Firebag SAGD Project	Suncor Firebag SAGD Project	Suncor Firebag SAGD Project
	Suncor Fort Hills Oil Sands Project	Suncor Fort Hills Oil Sands Project	Suncor Fort Hills Oil Sands Project
	Suncor MacKay River In-Situ Project	Suncor MacKay River In-Situ Project	Suncor MacKay River In-Situ Project
	Suncor Meadow Creek In-Situ Project	Suncor Meadow Creek In-Situ Project	Suncor Meadow Creek In-Situ Project

Table 5-1 Developments Included in the Assessment Cases (continued)

Status	Baseline Case	Application Case	Planned Development Case
Existing Cases (continued)	Suncor Millennium Project	Suncor Millennium Project	Suncor Millennium Project
	Suncor Millennium Dump 9 Project	Suncor Millennium Dump 9 Project	Suncor Millennium Dump 9 Project
	Suncor Steepbank Mine	Suncor Steepbank Mine	Suncor Steepbank Mine
	Suncor South Tailings Pond	Suncor South Tailings Pond	Suncor South Tailings Pond
	Suncor Voyageur Project	Suncor Voyageur Project	Suncor Voyageur Project
	Sunshine Harper CSS Pilot	Sunshine Harper CSS Pilot	Sunshine Harper CSS Pilot
	Sunshine West Ells Project	Sunshine West Ells Project	Sunshine West Ells Project
	Syncrude Aurora North Mine	Syncrude Aurora North Mine	Syncrude Aurora North Mine
	Syncrude Aurora South Mine	Syncrude Aurora South Mine	Syncrude Aurora South Mine
	Total E&P Joslyn North Mine	Total E&P Joslyn North Mine	Total E&P Joslyn North Mine
	Gas Production Facilities	Gas Production Facilities	Gas Production Facilities
	Other Industries	Other Industries	Other Industries
	Communities	Communities	Communities
Project		Cenovus Christina Lake Thermal Project – Phase H and Eastern Expansion	Cenovus Christina Lake Thermal Project – Phase H and Eastern Expansion
Planned Development			Athabasca Oil Corp. Birch Project
			Athabasca Oil Corp. Dover West Clastic Project Phase 1
			Athabasca Oil Corp. Dover West Leduc Carbonates Project Phase 1 and Phase 2 Demonstration
			Athabasca Oil Corp. Hangingstone Experimental In-Situ Project
			Athabasca Oil Corp. Hangingstone Commercial Project Phase 1
			Black Pearl Resources Inc. Blackrod Commercial Project
			Canadian Natural Birch Mountain East In-Situ Project
			Canadian Natural Gregoire Lake In-Situ Project
			Canadian Natural Grouse In-Situ Oil Sands Project
			Canadian Natural Kirby In-Situ Oil Sands Expansion Project
			Cavalier Energy Inc. Hoole Grand Rapids Project
			Cenovus Telephone Lake SAGD Project
			Cenovus Pelican Lake SAGD Project
			Cenovus Foster Creek Phase J
			CPC Surmont Commercial SAGD Project Phase 3
			Devon Pike 1 Project
			Devon Walleye Project
			Dover Operating Corp. Dover Commercial Project

Table 5-1 Developments Included in the Assessment Cases (continued)

Status	Baseline Case	Application Case	Planned Development Case
Planned Development (continued)			E-T Energy Poplar Creek ET-DSP Commercial Project
			Grizzly Oil Sands May River Project Phase 1
			Harvest Operating Corp. BlackGold Expansion
			Invanhoe Energy Tamarack Integrated Oil Sands Project
			Koch Muskwa Pilot
			Korea National Oil Corp Black Gold Exploration Project
			Laricina Germain Expansion Project
			Laricina Saleski Phase
			Marathon Oil Corp. Birchwood Demonstration
			MEG Surmont Project Oak Point Energy Lewis Steepbank Pilot
			OSUM Taiga Project
			Pengrowth Lindbergh Phase 1 Commercial Project
			Petrobank Energy & Resources May River Phase 1 Project
			Shell Jackpine Mine Expansion
			Shell Pierre River Mine
			Southern Pacific MacKay River Thermal Project Phase 2
			Statoil AKSA Kai Kos Dehseh SAGD Project – Hangingstone
			Statoil AKSA Kai Kos Dehseh SAGD Project – Leismer Northwest
			Statoil AKSA Kai Kos Dehseh SAGD Project – Leismer South
			Statoil AKSA Kai Kos Dehseh SAGD Project – Thornbury
			Statoil AKSA Kai Kos Dehseh SAGD Project – Thornbury Expansion
			Statoil Corner
			Statoil Leismer
			Statoil Thornbury
			Suncor Chard Project
			Suncor Firebag Stage 3 to 6 Debottlenecking
			Suncor Lewis SAGD Project
			Suncor Meadow Creek SAGD Project Expansion
			Suncor Voyageur South Project
			Sunshine Oil Sands West Ells A Phase 3, B Phase 1, B Phase 2 and C Phase 1

Table 5-1 Developments Included in the Assessment Cases (continued)

Status	Baseline Case	Application Case	Planned Development Case
Planned Development (continued)			Sunshine Oil Sands Legend Lake Phase 1
			Sunshine Oil Sands Thickwood Phase 1
			Surmont Energy Inc. Wildwood Phase 1
			Teck Frontier Oil Sands Mine Project
			Total E&P Joslyn South Mine Value Creation Inc. (VCI) TriStar Demonstration
			VCI Advanced TriStar Project
			Other industries
			Communities

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

6 REFERENCES

AENV, EUB and NRCB (Alberta Environment, Alberta Energy and Utilities Board, National Resources Conservation Board). 2010. *Cumulative Effects Assessment in Environmental Impact Assessment Reports Required Under the Alberta Environmental Protection and Enhancement Act*. Alberta Environment, the Energy and Utilities Board and the Natural Resources Conservation Board. Date published/Last modified: July 14, 2010. Edmonton, AB. 6 pp.

AENV (Alberta Environment). 2009. *Air Quality Model Guideline*. Prepared by A. Idriss and F. Spurrell. Climate Change, Air and Land Policy Branch, Alberta Environment. Revised May 2009. Edmonton, AB. 51 pp. ISBN: 978-0-7785-8512-1 (On-line); 978-0-7785-8511-4 (Print).

Andriashek, L.D. 2003. *Quaternary Geological Setting of the Athabasca Oil Sands (in-Situ) Area, Northeast Alberta*. Alberta Energy Utilities Board.

ASRD (Alberta Sustainable Resource Development). 2006. *The General Status of Alberta Wild Species 2005*. Alberta Sustainable Resource Development, Fish and Wildlife Service Division. Edmonton, AB.

Balls, V.A. 2012. *Historical Resources Impact Assessment for the Cenovus FCCL Ltd. Winefred Lake Lease Area (Permit 11-144)*. M.S. on file, Archaeological Survey of Alberta, Edmonton, AB.

Blower, D. 2007. *Historical Resources Impact Assessment: EnCana Christina Lake Thermal Expansion Project (Permit 07-186)*. M.S. on file, Archaeological Survey of Alberta. Edmonton, AB.

CEAA (Canadian Environmental Assessment Agency). 2003. *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners*. Prepared by the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment. November 2003. 48 pp.

CEMA (Cumulative Environmental Management Association). 2001. *CEMA Wildlife and Fish Working Group Priorities for Key Indicators*.

CEMA (Cumulative Environmental Management Association). 2006. *Sustainable Ecosystem Working Group (SEWG) Ratified Indicator List*. Fort McMurray, AB. 1 pp.

Cenovus (Cenovus FCCL Ltd.). 2010. Application for Approval of the Cenovus Narrows Lake Project. Integrated Application and Environmental Impact Assessment. Submitted to the Alberta Energy Resources Conservation Board and Alberta Environment. June 2010. Calgary, AB.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2007. *Canadian Species at Risk, January 2007*. Canadian Wildlife Service, Environment Canada. Ottawa, ON. 84 pp.

EnCana. 2009. *Christina Lake Thermal Project – Phase 1E, 1Fand 1G Expansion Application to the Alberta Energy and Utilities Board for an Amendment to Approval No. 8591 and Application to Alberta Environment for an Amendment to Approval No. 48522,* December 2009.

ESRD (Alberta Environment and Sustainable Resource Development). 2012. *Terms of Reference Environmental Impact Assessment Report for Cenovus FCCL Ltd.'s Proposed Christina Lake Thermal Project - Phase H and Eastern Expansion Approximately 20 km from Conklin, Alberta*. Issued by Alberta Environment and Sustainable Resources Development November 15, 2012. Edmonton, AB. 19 pp.

EUB (Alberta Energy and Utilities Board). 2007. *Directive 038: Noise Control Directive (February 16, 2007)*. Calgary, AB. 56 pp.

FEARO (Federal Environmental Assessment Review Office). 1994. *The Responsible Authority's Guide to the Canadian Environmental Assessment Act*.

Golder (Golder Associates Ltd.). 1999a. *Athabasca Oil Sands Cumulative Effects Assessment Framework Report*. Prepared for Cumulative Environmental Effects Management Initiative. 77 pp.

Golder (Golder Associates Ltd.). 1999b. *Potential Key Indicator Resources (KIRs) for the Mobil Kearl Oil Sands Project*. Prepared for Mobil Oil Canada Properties. Calgary, AB. 106 pp.

Government of Alberta. 2012. *Lower Athabasca Regional Plan 2012-2022*. Edmonton, AB. 98 pp. ISBN: 978-1-4601-0537-5 (Printed Version); 978-1-4601-0538-2 (Online Version).

Government of Canada. 2012. *Canadian Environmental Assessment Act, 2012 (S.C. 2012, C.19, S.52).* In force July 6, 2012. Act current to Janury 27, 2013. Last amended on December 14, 2012. Minister of Justice.

Hauge, T.M. and L.B. Keith. 1981. *Dynamics of Moose Populations in Northeastern Alberta*. Journal of Wildlife Management. 45. p. 573-5.

Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling, D. Stalker and AXYS (AXYS Environmental Consulting Ltd.). 1999. *Cumulative Effects Assessment Practitioners Guide*. Prepared by AXYS Environmental Consulting Ltd. and The CEA Working Group for the Canadian Environmental Assessment Agency. Hull, PQ. 134 pp.

MEG (MEG Energy Corp.). 2005. *Application for Approval of the Christina Lake Regional Project*. Volumes 1 to 5. Submitted to Alberta Environment and Alberta Energy and Utilities Board. Calgary, AB.

MEG (MEG Energy Corp.). 2008. *Application for Approval of the Christina Lake Regional Project - Phase 3, Integrated Application and Environmental Impact Assessment*. Volumes 1 to 6. Submitted to the Alberta Energy Resources Conservation Board and Alberta Environment. Calgary, AB. Submitted April 2008.

NRC (Natural Regions Committee). 2006. *Natural Regions and Subregions of Alberta*. D. J. Downing and W. W. Pettapiece (ed.). Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852. 254 pp.

PanCanadian (PanCanadian Resources). 1998. *Christina Lake Thermal Project: Application to Alberta Energy and Utilities Board and Alberta Environmental Protection: Twp 76, Rge 6 W4m*. Calgary, AB.

Pettapiece, W.W. 1986. *Physiographic Subdivisions of Alberta*. LRRC – Research Branch Agriculture Canada. Ottawa, ON.

Sadar, M.H. 1994. *Environmental Impact Assessment*. Carelton University (ed.). Carleton University Press for the Impact Assessment Centre.

Stuart-Smith, A.K., C.J.A. Bradshaw, S. Boutin, D.M. Hebert and A.B. Rippin. 1997. *Woodland Caribou Relative to Landscape Patterns in Northeastern Alberta*. Journal of Wildlife Management. 61. p. 622-633.

USDI (United States Department of the Interior). 1986. *BLM Manual Handbook H-8410-1 Visual Resource Inventory*. Bureau of Land Management.

7 ABBREVIATIONS

#	number
%	percent
<	less than
>	greater than
≤	less than or equal to
≥	greater than or equal to
°C	degrees Celsius
AAAQOs	Alberta Ambient Air Quality Objectives
AEE	Air Emissions Effects
AENV	Alberta Environment (predecessor to Alberta Environment and Water)
AEW	Alberta Environment and Water (predecessor to Alberta Environment and Sustainable Development)
bbl/d	barrels per day
BLCN	Beaver Lake Cree Nation
CEA	Cumulative Effects Assessment
CEMA	Cumulative Environmental Management Association
Cenovus	Cenovus FCCL Ltd.
CLFN	Cold Lake First Nations
CLTP	Christina Lake Thermal Project
CO_2	carbon dioxide
CPDFN	Chipewyan Prairie Dene First Nation
E	east
e.g.	for example
EIA	Environmental Impact Assessment
EPEA	Alberta *Environmental Protection and Enhancement Act*
ERCB	Energy Resources Conservation Board
ESRD	Alberta Environment and Sustainable Resource Development
et al.	and others

EUB	Alberta Energy and Utilities Board (predecessor to the Energy Resources Conservation Board [ERCB])
FCCL	Foster Creek-Christina Lake
FMFN	Fort McMurray First Nation
GTG/HRSGs	Gas Turbine Generators/Heat Recovery Steam Generators
ha	hectare
HLFN	Heart Lake First Nation
HRIA	Historic Resources Impact Assessment
i.e.	that is
IR	Indian Reserve
keq H^+/ha/y	kiloequivalent of hydrogen per hectares per year
KIRs	Key Indicator Resources
km	kilometre
km^2	square kilometre
LIDAR	Light Detection and Ranging
LSA	Local Study Area
m	metre
m^3/d	cubic metres per day
masl	metres above sea level
N	north
NAD	North American Datum
NO_x	oxides of nitrogen
PAH	polycyclic aromatic hydrocarbons
PDC	Planned Development Case
PM	particulate matter

$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 microns (µm) or less
RAMP	Regional Aquatics Monitoring Program
RFMA	Registered Fur Management Area
Rge	Range
RSA	Regional Study Area
RSDS	Regional Sustainable Development Strategy
S	south
SAGD	Steam Assisted Gravity Drainage
SARA	*Species at Risk Act*
SEWG	Sustainable Ecosystems Working Group of CEMA
t/d	tonnes per day
the Project	Christina Lake Thermal Project – Phase H and Eastern Expansion
TLU	Traditional Land Use
TOR	Terms of Reference
TWP	Township
UTM	Universal Transverse Mercator
W	west
W4M	West of the Fourth Meridian

8 GLOSSARY

Acute	A stimulus severe enough to rapidly induce an effect; in aquatic toxicity tests, an effect observed in 96 hours or less is typically considered acute. When referring to aquatic toxicology or human health, an acute effect is not always measured in terms of lethality.
Alberta Ambient Air Quality Objective (AAAQO)	Levels established for several air compounds under Section 14 of the *Environmental Protection and Enhancement Act*. The Alberta Ambient Air Quality Objectives 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)	See *Alberta Environment and Sustainable Resource Development*.
Alberta Environment and Sustainable Resource Development (ESRD)	Provincial ministry that 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. The ministry was formed in May 2012 to bring together the former departments of Environment and Water, and Sustainable Resource development; ESRD's predecessors were Alberta Environment and Water (from October 2011 to May 2012), and Alberta Environment.

Application Case The Environmental Impact Assessment (EIA) case including the project that is the subject of the application, existing environmental conditions, and existing and approved projects or activities.

Baseline Case The EIA assessment case that includes existing environmental conditions as well as existing and approved projects or activities.

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.

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.
Carnivore	Any of an order of mammals that feed chiefly on flesh or other animal matter rather than plants.
Chronic	The development of adverse effects after extended exposure to a given substance. In chronic toxicity tests, the measurement of a chronic effect can be reduced growth, reduced reproduction or other non-lethal effects, in addition to lethality. Chronic should be considered a relative term depending on the life span of the organism. Considered to be long-term, repeated or continuous exposure.
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.
Dissolved Organic Carbon (DOC)	The dissolved portion of organic carbon water; made up of humic substances and partly degraded plant and animal materials.
Ecodistrict	A broad subdivision of the landscape based on differences in landscape pattern, topography and dominant soils.
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.

Energy Resources Conservation Board (ERCB)	An independent, quasi-judicial agency of the Government of Alberta. The ERCB was created on January 1, 2008 as a result of the realignment of the Alberta Energy and Utilities Board (EUB) into the ERCB and the Alberta Utilities Commission (AUC). The ERCB also includes the Alberta Geological Survey. The purpose of the ERCB is to ensure that the discovery, development and delivery of Alberta's energy resources take place in a manner that is fair, responsible and in the public interest. The ERCB regulates the safe, responsible, and efficient development of Alberta's energy resources: oil, natural gas, oil sands, coal and pipelines.
Environmental Impact Assessment (EIA)	A review of the effects that a proposed development will have on the local and regional environment.
***Environmental Protection and Enhancement Act* (EPEA) (Alberta)**	The purpose of the act is to support and promote the protection, enhancement and wise use of the environment.
Eutrophication	The over fertilization of a body of water, which generally results in increased plant growth and decay. This ultimately leads to an increase in simple algae and plankton over more complex plant species, resulting in a decrease in water quality. Causes of eutrophication can be anthropogenic or natural.
Fish	Fish as defined in the Fisheries Act, includes parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
Fish Habitat	Fish habitat, as defined in the *Fisheries Act*, includes the spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes.
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).

Fumigation	Exposure to potentially toxic substances such as sulphur dioxide (SO_2) or nitrogen dioxide (NO_2) in gaseous form.
Glaciolacustrine	Sediments that were deposited in lakes that formed at the edge of glaciers when the glaciers receded. Glaciolacustrine sediments are commonly laminar deposits of fine sand, silt and clay.
Greenhouse Gases	Gases such as carbon dioxide (CO_2), water vapour, methane (CH_4), nitrous oxide (N_2O), and other trace gases which trap heat in the atmosphere, producing the greenhouse effect.
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.
Habitat Fragmentation	Occurs when extensive, continuous tracts of habitat are reduced by habitat loss to dispersed and usually smaller patches of habitat. Generally reduces the total amount of available habitat and reduces remaining habitat into smaller, more isolated patches.
Historic Resources	Works of nature or of humans, valued for their palaeontological, archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest.
Hummocky	A very complex sequence of slopes extending from somewhat rounded depression or kettles or various sizes to irregular to conical knolls or knobs. There is a general lack of concordance between knolls and depressions.
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.
Key Indicator Resources	Environmental attributes or components identified as a result of a social scoping exercise as having legal, scientific, cultural, economic or aesthetic value.

Lease Area	The project area includes all lands subject to direct disturbance from the project and associated infrastructure.
Local Study Area	Defines the spatial extent directly or indirectly affected by the project.
Oil Sands	A sand deposit containing a heavy hydrocarbon (bitumen) in the intergranular pore space of sands and fine grained particles. Typical oil sands comprise approximately 10 wt% bitumen, 85% coarse sand (>44 μm) and a fines (<44 μm) fraction, consisting of silts and clays.
Once Through Steam Generator (OTSG)	The most commonly used boiler in oilfield operations. An OTSG is a large vessel with pipes running through it. Water is introduced into the pipes at the inlet of the natural gas fired boiler, and steam exits from the pipes at the outlet.
Oxides of Nitrogen	Oxides of nitrogen include gaseous compounds such as nitrogen oxide (NO) and nitrogen dioxide (NO_2), but may also include additional nitrogen species (e.g., N_2O, N_3O). NO_x are the primary precursor for trophospheric ozone. A measure of the oxides of nitrogen comprised of nitric oxide (NO) and nitrogen dioxide (NO_2).
Ozone (O_3)	A gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone in the upper atmosphere protects living organisms by preventing damaging ultraviolet light from reaching the Earth's surface. Ground-level ozone is an air pollutant with harmful effects on the respiratory systems of animals.
Particulate Matter	A mixture if small particles and liquid droplets, often including a number of chemicals, dust and soil particles.
Peatland	Areas where there is an accumulation of peat material at least 40 cm thick. These areas are represented by bog and fen wetlands types.
pH	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.

Planned Development Case	The Planned Development Case includes the Application Case components and planned developments that have been publicly disclosed at least six months prior to submission of the Environmental Impact Assessment.
$PM_{2.5}$	Airborne particulate matter with a mean diameter less than 2.5 µm (microns) in diameter. This represents the fraction of airborne particles that can be inhaled deeply into the pulmonary tissue.
Polycyclic Aromatic Hydrocarbon (PAH)	Polycyclic aromatic hydrocarbons are a large group of organic compounds comprised of two or more aromatic rings and by-products of combustion. They are found in crude oil and a variety of products such as bitumen, asphalt, coal tar pitch volatiles, and unrefined or mildly refined mineral oils. Polycyclic aromatic hydrocarbons (PAHs) are emitted into the Canadian environment from both natural and anthropogenic sources. Forest fires, which release approximately 2,000 tonnes of PAHs per year, are the single most important natural source of PAHs in Canada. However, since releases from that source are generally widely separated in time and space across the country, they do not result in continuous exposure in any specific area. Anthropogenic sources are numerous and result in emissions of PAHs into all environmental compartments.
Receptor	The person or organism subjected to exposure to chemicals or physical agents.
Receptor (noise)	A location where measurements or predictions of noise levels are made.
Regional Study Area	Represents the area of study for the assessment of cumulative (combined) effects of the Project and other past, existing or planned developments.
Riparian	Terrain, vegetation or a position next to or associated with a stream, floodplain or standing waterbody.
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.

Sediments	Material that settles to the bottom of lakes, rivers and creeks.
Sentinel Species	Species that can be used as an indicator of environmental conditions
Soil	The naturally occurring, unconsolidated mineral or organic material at least 10 cm thick that occurs at the earth's surface and is capable of supporting plant growth.
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 Fish	Large fish caught for food or sport (e.g., northern pike, Arctic grayling).
Stakeholders	Members of the public and special interest groups, federal authorities, provincial or municipal government, landowners or other parties who have an interest in the proposed project.
Steam Assisted Gravity Drainage (SAGD)	An enhanced oil recovery technique that involves drilling pairs of horizontal wells into underground formations, and injecting steam. The steam is pumped into the upper well, heats the oil, and causes the oil to flow into the bottom well so it can be pumped to the surface.
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.
Terms of Reference	The Terms of Reference identify the information required by government agencies for an Environmental Impact Assessment.
Traditional Ecological Knowledge	Aboriginal 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 rivers, streams, and lakes.

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.

Well Pair In SAGD terms, a well pair consists of a horizontal production well that is drilled at or close to the base of the SAGD zone, and a horizontal injection well drilled the same length as, and approximately 5m above, the producer. The injector injects steam into the SAGD zone, and the producer (using a specified lift system) produces emulsion (oil, condensed steam, and formation water) to the surface.

Wetlands Area where the water table is at, near or above the surface or that 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.

TERMS OF REFERENCE
ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR CENOVUS FCCL LTD.'s PROPOSED

CHRISTINA LAKE THERMAL PROJECT – PHASE H AND EASTERN EXPANSION

Approximately 20 km from Conklin, Alberta

ISSUED BY: **Alberta Environment and Sustainable Resource Development**

DATE: **November 15, 2012**

TABLE OF CONTENTS

PURPOSE OF THE TERMS OF REFERENCE

The purpose of this document is to identify for Cenovus FCCL Ltd., as operator for FCCL Partnership, (Cenovus), 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 Project – Phase H and Eastern Expansion (the Project).

Cenovus is proposing to expand its in situ oil sands project in the Southern Athabasca Oil Sands region approximately 20 km southeast of Conklin in Townships 75 & 76, Ranges 4 through 6, west of the 4th Meridian. The Project is a 50/50 joint venture with ConocoPhillips Canada and will be operated by Cenovus. Steam Assisted Gravity Drainage (SAGD) technologies will be employed to recover bitumen resources from the McMurray Formation.

Cenovus currently operates in an area located south of Christina Lake having recently submitted an amendment application that would bring the cumulative production capacity of the asset up to 238,800 bbl/day (37,969 m^3/day). Resource delineation of additional assets has identified bitumen resource adjacent to the present Christina Lake operational area that would support the production of an additional estimated 50,000 bbl/day. Total approved production would increase to 288,800 bbl/day.

The main infrastructure required to support the addition of the Phase H and Eastern Expansion area will include a central processing facility (to be built in a previously approved and cleared location) and associated shared infrastructure such as pipelines, roads, borrow areas and powerlines necessary to support approximately 190 new well pads. Each pad will have a full production life of approximately 25 years given the current technologies. Expansion associated with the Project will occur within areas previously assessed as part of the Christina Lake Phases E, F, and G Environmental Impact Assessment (EIA) submitted in 2009 and within an area to the east known as the Kirby East expansion area.

The Project will employ the same well established Steam Assisted Gravity Drainage (SAGD) in situ resource recovery methods utilized at the existing CLTP operations to recover bitumen.

The CLTP commercial project has operated since 2002. Through two previous EIA's and on-going environmental monitoring, significant information is known about the area. Cenovus plans to incorporate this accumulated knowledge into the Project EIA. These Terms of Reference recognize the location of the CLTP Phase H and Eastern expansion, the existing dataset and operating experience, and therefore have been tailored with the emphasis of the EIA and assessment of cumulative effects on specific areas of potential concern. For areas where there have been learnings from the existing/approved CLTP project, Cenovus intends on highlighting the adaptive environmental and regulatory management systems currently in place and the results of monitoring programs to improve the assessment of the potential impacts of the Project. The specific content of each environmental assessment area will be as identified in the Terms of Reference.

SCOPE OF THE EIA REPORT

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

The EIA report shall be prepared considering all applicable provincial and federal legislation, codes of practice, guidelines, standards, policies and directives.

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 the Proponent's application to the Energy Resources Conservation Board (ERCB). An EIA report summary will also be included as part of the ERCB Application.

The Proponent 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 Environmental Impact Assessment 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.

CONTENT OF THE EIA REPORT

1 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION

[A] Describe the concerns and issues expressed by the public and the actions taken to address those concerns and issues, including how public input was incorporated into the Project development, impact mitigation and monitoring.

[B] Describe the concerns and issues expressed by aboriginal communities and the actions taken to address those concerns and issues, including how aboriginal community input was incorporated into the Project, EIA development, mitigation, monitoring and reclamation. Describe consultation undertaken with aboriginal communities and groups with respect to traditional ecological knowledge, rights and traditional use of land and water.

[C] Discuss the Proponent's aboriginal consultation for the Project considering the approved First Nations Consultation Plan.

[D] Describe plans to maintain the public engagement and aboriginal consultation process following completion of the EIA report 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 Overview

[A] Provide a brief project description in sufficient detail to provide context for the EIA, including:

a) proponent information;
b) proposed extraction and bitumen processing technology;
c) amount and source of energy required for the Project;
d) water supply and disposal requirements, including process water and potable water requirements;
e) proposed method to transport product to markets; and
f) development plan and schedule.

[B] 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.

[C] Discuss the implications of a delay in proceeding with the Project, or any phase of the Project, or not going ahead with the Project.

[D] Describe the benefits of the project, including jobs created, local training, employment and business opportunities, and royalties and taxes generated that accrue to:
a) Cenovus;
b) local and regional communities, including Aboriginal communities;
c) the local authority;
d) Alberta; and
e) Canada.

[E] Provide the adaptive management approach that will be implemented throughout the life of the Project. Include how monitoring, mitigation and evaluation were incorporated.

2.2 Relationship of the Phase H and Eastern Expansion to the existing/approved Christina Lake Development (Phases A to G)

[A] Describe the history of the existing Christina Lake Development.

[B] Provide maps showing the EIA study areas for Christina Lake and the proposed Project Area for the Phase H and Eastern Expansion. Discuss the implications of any overlaps in the mapped areas, including the confidence Cenovus has in the data and assessments from the previous Christina Lake developments as they apply to the Phase H and Eastern Expansion and the need for additional field studies to fill any gaps.

[C] Describe for each EIA discipline the lessons learned from the planning, design, construction, operation, mitigation and monitoring of the existing Christina Lake Development.

[D] Describe for each EIA discipline the lessons learned from the public engagement and aboriginal consultation process and the approvals process for the existing Christina Lake Development.

[E] Describe how the lessons learned have been incorporated into the design of the Phase H and Eastern Expansion.

2.3 Constraints

[A] Discuss the process and criteria used to identify constraints to development, and how the Project has been designed to accommodate those constraints. Include the following:
a) any applicable *Alberta Land Stewardship Act* Regional Plan;
b) land use policies and resource management initiatives that pertain to the Project;
c) how this project aligns with the Comprehensive Regional Infrastructure Sustainability Plan for the Athabasca Oil Sands Area. Include transportation, general infrastructure and consolidated project accommodations in the analysis;
d) Aboriginal traditional land and water use;
e) all known traplines;
f) the environmental setting;
g) cumulative environmental impacts in the region;
h) cumulative social impacts in the region;
i) results of Project-specific and regional monitoring;

j) potential for new or additional technology to increase resource recovery at later times;
k) potential for changes in the regulatory regime; and
l) new protected areas through the Lower Athabasca Regional Plan administered by Alberta Tourism, Parks, and Recreation, such as the new Winefred Lake Provincial Recreation Area.

[B] Discuss the selection criteria used, options considered, and rationale for selecting:
a) location of facilities and infrastructure (including linear infrastructure) with consideration of placements for future expansion(s);
b) thermal energy and electric power required for the Project.
c) water supply sources;
d) wastewater treatment, management and disposal;
e) air emission and air quality management; and
f) waste disposal.

[C] Provide a list of facilities for which locations will be determined later. Discuss the selection criteria that will be used to determine the specific location of these facilities.

2.4 Regional and Cooperative Efforts

[A] Discuss the Proponent's involvement in regional and cooperative efforts to address environmental and socio-economic issues associated with regional development.

[B] Describe opportunities for sharing infrastructure (e.g., access roads, utility corridors, water infrastructure) with other resource development stakeholders. Provide rationale where these opportunities will not be implemented.

2.5 Transportation Infrastructure

[A] Prepare a Traffic Impact Assessment (TIA) as per Alberta Transportation's TIA Guideline (http://www.transportation.alberta.ca/613.htm). If there are any previous Traffic Impact Assessment studies that have been carried out for the Project or adjacent Projects using the same access, review and validate the findings and recommendations.
a) describe the anticipated changes to highway traffic (e.g., type, volume) due to the Project;
b) assess potential traffic impacts for all stages of the Project; and
c) consider other existing and planned uses of the same highway.

[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; and
c) provide a proposed schedule for the work.

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

2.6 Air Emissions Management

[A] Discuss the selection criteria used, options considered, and rationale for selecting control technologies to minimize air emission and ensure air quality management.

[B] 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 and 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 detailed calculations;
c) the intensity of greenhouse gas emissions per unit of bitumen produced;
d) the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis;
e) Cenovus' overall greenhouse gas management plans;
f) amount and nature of Criteria Air Contaminants emissions;
g) the amount and nature of acidifying emissions, probable deposition patterns and rates;
h) emergency flaring scenarios (e.g., frequency and duration) and proposed measures to ensure flaring events are minimized;
i) upset condition scenarios (e.g., frequency and duration) and proposed measures to ensure upset conditions are minimized;
j) gas collection and conservation, and the applicability of vapour recovery technology;
k) applicability of sulphur recovery, acid gas re-injection or flue gas desulphurization to reduce sulphur emissions; and
l) fugitive emissions control technology to detect, measure and control emissions and odours from equipment leaks.

2.7 Water Management

2.7.1 Water Supply

[A] Describe the water supply requirements for the entire Cenovus Christina Lake Project, and for the expansion specifically outline:

a) the criteria used, options considered and rationale for selection of water supply sources(s);
b) the expected water balance during all stages of the Project. Discuss assumptions made or methods chosen to arrive at the water balances;
c) the process water, potable water, and non-potable water requirements and sources for construction (including but not limited to road construction, winter road construction, lease construction, production well drilling and dust suppression), camp(s) and plant site, 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;
d) the location of sources/intakes and associated infrastructure (e.g., pipelines for water supply);
e) the variability in the amount of water required on an annual and seasonal basis as the Project is implemented;
f) describe contingency plans in the event of restrictions on the Projects water supply source (e.g., due to license conditions, source volume limitations, climate change or cumulative impact water deficits);
g) the expected cumulative effects on water losses/gains resulting from the Project operations;
h) annual and total freshwater use, both for the expansion and for the Project as a whole;
i) potable water treatment systems for all stages of the Project;
j) type and quantity of potable water treatment chemicals used; and

k) 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.

2.7.2 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 and map crossings of watercourses or waterbodies (including bridges, culverts and pipelines) required and provide example diagrams of each type of crossing.

[C] Describe the placement of infrastructure (including processing facilities, well pads, roads and borrow pits) in relation to waterbodies and watercourses.

2.7.3 Wastewater Management

[A] Describe the wastewater management strategy, including:

a) the criteria used, options considered and rationale for the selection of wastewater treatment and wastewater disposal;
b) 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;
c) the proposed disposal locations and methods for each wastewater stream;
d) geologic formations for the disposal of wastewaters;
e) design of facilities that will collect, treat, store and release wastewater streams;
f) type and quantity of chemicals used in wastewater treatment; and
g) sewage treatment and disposal.

2.8 Waste Management

[A] Discuss the selection criteria used, options considered, and rationale for waste disposal.

[B] 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) describe how the disposal sites and sumps will be constructed; and
c) describe plans for pollution prevention, waste minimization, recycling, and management to reduce waste quantities for all stages of the Project.

2.9 Conservation and Reclamation

[A] Provide a conceptual conservation and reclamation plan for the Project. Describe and map as applicable:

a) current land use and capability and proposed post-development land use and capability;
b) 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;
c) constraints to reclamation such as timing of activities, availability of reclamation materials and influence of natural processes and cycles including natural disturbance regimes;
d) a revegetation plan for the disturbed terrestrial, riparian and wetland areas;
e) reclamation material salvage, storage areas and handling procedures; and
f) existing and final reclaimed site drainage plans.

[B] Discuss, from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and wildlife habitat, the expected success of establishment and recovery, and the expected differences in the resulting communities.

[C] Describe how Cenovus considered the use of progressive reclamation in project design and reclamation planning.

[D] Discuss Cenovus' involvement in any in-situ reclamation initiatives or reclamation working groups.

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

3 ENVIRONMENTAL ASSESSMENT

3.1 Air Quality, Climate and Noise

3.1.1 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.

3.1.2 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;
b) estimate ground-level concentrations of appropriate air quality parameters;
c) discuss any expected changes to particulate deposition, nitrogen deposition or acidic deposition patterns;
d) identify areas that are predicted to exceed Potential Acid Input (PAI) critical loading criteria; and
e) discuss interactive effects that may occur resulting from co-exposure of a receptor to all emissions.

[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 and discuss the potential impacts over the life of the Project.

[C] Summarize the results of the noise assessment conducted for the ERCB, and:
a) identify the nearest receptor used in the assessment; and
b) discuss the design, construction and operational factors to be incorporated into the Project to comply with the ERCB's Directive 38: Noise Control.

3.2 Hydrogeology

3.2.1 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 disposal zones, and:
a) present regional and Project Area geology to illustrate depth, thickness and spatial extent of lithology, stratigraphic units and structural features; and
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 resulting from 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.

3.2.2 Impact Assessment

[A] Describe Project components and activities that have the potential to affect groundwater resource quantity and quality at all stages 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 both groundwater and surface water quantity and quality;
b) implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands;
c) changes in groundwater quality, quantity and flow;
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.

3.3 Hydrology and Hydraulics

3.3.1 Baseline Information

[A] Describe and map the surface hydrology in the Project Area. Include flow regime 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.

3.3.2 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, during all phases of the project, 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 the 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 resulting from the Project.

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

[D] Describe impacts on other surface water users resulting from 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] Describe residual effects of the Project on hydrology and Cenovus' plans to manage those effects.

3.4 Surface Water Quality

3.4.1 Baseline Information

[A] Describe the baseline water quality of watercourses and waterbodies.

3.4.2 Impact Assessment

[A] Describe the potential impacts of the Project on surface water quality.

3.5 Aquatic Ecology

3.5.1 Baseline Information

[A] Describe and map the fish, fish habitat and aquatic resources (e.g., aquatic and benthic invertebrates) of the lakes, rivers, ephemeral water bodies and other waters. Describe the species composition, distribution, relative abundance, movements and general life history parameters of fish resources. Also identify any species that are:

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

[B] Describe and map existing critical or sensitive areas such as spawning, rearing, and over-wintering habitats, seasonal habitat use including migration and spawning routes. Provide a map of proposed drill paths overlain on surface hydrology.

[C] Describe the current and potential use of the fish resources by aboriginal, sport or commercial fisheries.

3.5.2 Impact Assessment

[A] Describe and assess the potential impacts of the Project to fish, fish habitat, and other aquatic resources, considering:

a) potential habitat loss and alteration;
b) potential water quality and quantity changes;
c) potential impacts on riparian areas that could affect aquatic biological resources and productivity;
d) changes to benthic invertebrate communities that might affect food quality and availability for fish;
e) potential increased fishing pressures in the region that could arise from the increased workforce and predicted regional population, and improved access from the Project. Characterize the current use of local and regional fisheries resources to support the assessment of potential changes in angling pressure;
f) potential increased habitat fragmentation;
g) potential acidification;
h) potential groundwater-surface water interactions;
i) potential for thermal plumes to interact with aquatic habitat;
j) potential for ground heave and impacts to surface water flow and aquatic habitat;
k) potential impacts to traditional use of aquatic resources; and
l) potential entrapment and entrainment of fish at water intakes.

[B] Identify the key aquatic indicators that the Proponent used to assess project impacts. Discuss the rationale for their selection.

[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.

3.6 Vegetation

3.6.1 Baseline Information

[A] Describe and map the vegetation communities, wetlands, rare plants, old growth forests, and communities of limited distribution. Identify the occurrence, relative abundance and distribution and identify any species that are:

a) listed as "at Risk, May be at Risk and Sensitive" in the General Status of Alberta Wild Species (Alberta Environment and Sustainable Resource Development);
b) listed in Schedule 1 of the federal *Species at Risk Act*;
c) listed as "at risk" by COSEWIC; and
d) traditionally used species.

[B] Describe and quantify the current extent of habitat fragmentation.

3.6.2 Impact Assessment

[A] Identify key vegetation indicators to assess the Project impacts. Discuss the rationale for the indicator's selection.

[B] Describe and assess the potential impacts of the Project on vegetation communities including wetlands, rare plants, old growth forests and communities of limited distribution, considering:

a) both temporary (include timeframe) and permanent impacts;
b) the potential for introduction and colonization of weeds and non-native invasive species;
c) potential increased fragmentation and loss of upland, riparian and wetland habitats; and
d) implications of vegetation changes for other environmental resources (e.g., terrestrial and aquatic habitat diversity and quantity, water quality and quantity, erosion potential).

3.7 Wildlife

3.7.1 Baseline Information

[A] Describe and map the wildlife resources (amphibians, reptiles, birds, and terrestrial and aquatic mammals). Describe species relative abundance, distribution and their use and potential use of habitats. Also identify any species that are:

a) listed as "at Risk, May be at Risk and Sensitive" in the General Status of Alberta Wild Species (Alberta Environment and Sustainable Resource Development);
b) listed in Schedule 1 of the federal *Species at Risk Act*;
c) listed as "at risk" by COSEWIC; and
d) traditionally used species.

[B] Describe and map existing wildlife habitat and habitat disturbance (including exploration activities). Identify those habitat disturbances that are related to existing and approved projects.

3.7.2 Impact Assessment

[A] Describe and assess the potential impacts of the Project to wildlife and wildlife habitats, considering:

a) how the Project will affect wildlife relative abundance, habitat availability, mortality, movement patterns, and distribution for all stages of the Project;

b) how Cenovus will meet the *Woodland Caribou Policy for Alberta* and the federal *Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population, in Canada*;
c) how improved or altered access may affect wildlife;
d) 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 predator-prey relationships;
e) potential effects on wildlife resulting from changes to air and water quality, including both acute and chronic effects to animal health; and
f) potential effects on wildlife from the Proponent's proposed and planned exploration, seismic and core hole activities, including monitoring/4D seismic.

[B] Identify the key wildlife and habitat indicators used to assess Project impacts. Discuss the rationale for their selection.

3.8 Biodiversity

3.8.1 Baseline Information

[A] Describe and map the existing biodiversity.

[B] Identify the biodiversity metrics, biotic and abiotic indicators that are used to characterize the baseline biodiversity. Discuss the rationale for their selection.

3.8.2 Impact Assessment

[A] Describe and assess the potential impacts of the Project to biodiversity considering:
a) the biodiversity metrics, biotic and abiotic indicators selected;
b) the effects of fragmentation on biodiversity potential;
c) the contribution of the Project to any anticipated changes in regional biodiversity and the potential impact to local and regional ecosystems; and
d) effects during construction, operations and post-reclamation and the significance of these changes in a local and regional context.

3.9 Terrain and Soils

3.9.1 Baseline Information

[A] Describe and map the terrain and soils conditions in the Project Area.

[B] Describe and map soil types in the areas that are predicted in 3.1.2[A]d) to exceed Potential Acid Input (PAI) critical loading criteria.

3.9.2 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) discuss the relevance of any changes for the local and regional landscapes, biodiversity, productivity, ecological integrity, aesthetics and future use;
c) identify the potential acidification impact on soils and discuss the significance of predicted impacts by acidifying emissions; and
d) describe potential sources of soil contamination.

[B] Discuss:

a) the environmental effects of proposed drilling methods on the landscape and surficial and bedrock geology;
b) 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
c) the potential impacts caused by the mulching and storage of woody debris considering, but not limited to vulnerability to fire, degradation of soil quality, increased footprint, etc.

3.10 Land Use and Management

3.10.1 Baseline Information

[A] Describe and map the current land uses in the Project Area, including all Crown land and Crown Reservations (Holding Reservation, Protective Notation, Consultative Notation).

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

[C] Identify and map unique sites or special features in the Project Area and Local Study Area such as Parks and Protected Areas (current and proposed), Heritage Rivers, Historic Sites, Environmentally Significant Areas, culturally significant sites and other designations (World Heritage Sites, Ramsar Sites, Internationally Important Bird Areas, etc).

[D] Describe and map land clearing activities, showing the timing of the activities.

[E] Describe the status of timber harvesting arrangements, including species and timing.

[F] Describe existing access control measures.

3.10.2 Impact Assessment

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

a) unique sites or special features;
b) changes in public access arising from linear development, including secondary effects related to increased hunter, angler and other recreational access, and facilitated predator movement;
c) aggregate reserves that may be located on land under the Proponent’s control and reserves in the region;
d) development and reclamation on commercial forest harvesting and fire management in the Project Area;
e) the amount of commercial and non-commercial forest land base that will be disturbed by the Project, including the Timber Productivity Ratings for the Project Area. Compare the baseline and reclaimed percentages and distribution of all forested communities in the Project Area;
f) how the Project impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area;
g) how the Project impacts current and proposed parks and protected areas;
h) anticipated changes (type and extent) to the topography, elevation and drainage patterns within the Project Area; and
i) access control for public and regional recreational activities aboriginal land use and other land uses during and after development activities.

[B] 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.

4 HISTORIC RESOURCES

[A] Describe the Historic Resource Impact Assessment (HRIA) work done to date for the Project, and provide a schedule for any future work.

[B] Describe the implications of the findings of the HRIA work on Project design and scheduling.

[C] Describe any Project uncertainties arising from the need for future HRIA work.

4.1 Baseline Information

[A] Provide a brief overview of the regional historical resources setting including a discussion of the relevant archaeological, historic and palaeontological records.

[B] Describe and map known historic resources sites in the Project area, considering:

a) site type and assigned Historic Resources Values (HRVs); and
b) existing site specific *Historical Resources Act* requirements (if applicable).

[C] Provide an overview of previous Historical Resources Impact Assessments (HRIAs) that have been conducted within the Project Area, including:

a) a description of the spatial extent of previous assessment relative to the Project Area, noting any assessment gap areas; and
b) a summary of *Historical Resources Act* requirements and/or clearances that have been issued for the Project to date (if applicable).

[D] Identify locations within the Project Area that are likely to contain previously unrecorded historic resources. Thoroughly describe the methods used to identify these areas.

4.2 Impact Assessment

[A] Describe Project components and activities that have the potential to affect historic resources at all stages of the Project.

[B] Describe the nature and significance of the potential Project impacts on historical resources, considering:

a) effects on historic resources site integrity; and
b) implications for the interpretation of the archaeological, historic and palaeontological records.

5 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE

[A] Provide:

a) a map and description of traditional land use areas including fishing, hunting, trapping and nutritional, medicinal or cultural plant harvesting by affected aboriginal peoples (if the aboriginal community or group is willing to have these locations disclosed);
b) a map of cabin sites, spiritual sites, cultural sites, graves and other traditional use sites considered historic resources under the *Historical Resources Act* (if the

aboriginal community or group is willing to have these locations disclosed), as well as traditional trails and resource activity patterns; and

c) a discussion of:
   i) the availability of vegetation, fish and wildlife species for food, traditional, medicinal and cultural purposes in the identified traditional land use areas considering all Project related impacts,
   ii) access to traditional lands in the Project Area during all stages of the Project, and
   iii) aboriginal views on land reclamation.

[B] Describe how TEK and TLU information was incorporated into the Project, EIA development, the conservation and reclamation plan, monitoring and mitigation.

[C] Determine the impacts of the Project on traditional, medicinal and cultural purposes and identify possible mitigation strategies.

6 PUBLIC HEALTH AND SAFETY

6.1 Public Health

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

[B] Document any health concerns raised by stakeholders during consultation on the Project.

[C] 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. Describe how you plan to mitigate these concerns.

[D] Describe the potential health impacts resulting from higher regional traffic volumes and the increased risk of accidental leaks and spills.

6.2 Public Safety

[A] 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 the Proponent'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; and
e) describe the potential safety impacts resulting from higher regional traffic volumes.

7 SOCIO-ECONOMIC ASSESSMENT

7.1 Baseline Information

[A] Describe the existing socio-economic conditions in the region and in the communities in the region.

[B] Describe factors that may affect existing socio-economic conditions including:
a) population changes;
b) workforce requirements for the Project, including a description of when peak activity periods will occur;
c) planned accommodations for the workforce for all stages of the Project;
d) Cenovus' policies and programs regarding the use of local, regional and Alberta goods and services;
e) the project schedule; and
f) the overall engineering and contracting plan for the Project.

7.2 Impact Assessment

[A] Describe the effects of construction and operation of the Project on:
a) housing;
b) availability and quality of health care services;
c) local and regional infrastructure and community services;
d) recreational activities;
e) parks and protected areas;
f) hunting, fishing, trapping and gathering; and
g) First Nations and Métis (e.g., traditional land use and social and cultural implications).

[B] Discuss how Cenovus is utilizing existing camp infrastructure for the Project or how workers for the Project will be housed. With the use of an existing camp, discuss the camp location, the number of workers from this Project that will use the camp and the percentage of occupancy this Project will utilize.

[C] Describe the need for additional Crown land to manage the effects in [A] and [B].

[D] Discuss opportunities to work with First Nation and Métis communities and groups, other local residents and businesses regarding employment, training needs and other economic development opportunities arising from the Project.

[E] Provide the 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.

8 MITIGATION MEASURES

[A] Discuss mitigation measures to avoid, minimize or eliminate the potential impacts for all stages of the Project.

[B] Identify mitigation objectives and those mitigation measures that will be implemented for each associated impact and provide rationale for their selection, including a discussion on the effectiveness of the proposed mitigation.

9 RESIDUAL IMPACTS

[A] Describe the residual impacts of the Project following implementation of the Proponent's mitigation measures and the Proponent's plans to manage those residual impacts.

10 MONITORING

[A] Describe Cenovus' current monitoring programs for Christina Lake Thermal Project.

[B] Describe any new monitoring that will be required as a result of this project, including:

a) how the monitoring programs will assess any project impacts and measure the effectiveness of mitigation plans. Discuss how the Proponent will address any Project impacts identified through the monitoring program; and
b) how the results of monitoring programs and publicly available monitoring information will be integrated with the Proponent's environmental management system and how it will be used to manage environmental effects, confirm performance of mitigation measures, and improve environmental protection strategies.

[C] Discuss the Proponent's current and proposed monitoring programs, including:

a) how the monitoring programs will assess any project impacts and measure the effectiveness of mitigation plans. Discuss how the Proponent will address any Project impacts identified through the monitoring program;
b) how the Proponent will contribute to current and proposed regional monitoring programs;
c) monitoring performed in conjunction with other stakeholders, including aboriginal communities and groups;
d) new monitoring initiatives that may be required as a result of the Project;
e) regional monitoring that will be undertaken to assist in managing environmental effects and improve environmental protection strategies;
f) how monitoring data will be disseminated to the public, aboriginal communities or other interested parties; and
g) how the results of monitoring programs and publicly available monitoring information will be integrated with the Proponent's environmental management system and how it will be used to manage environmental effects, confirm performance of mitigation measures, and improve environmental protection strategies.

APPENDIX 2-II

CONCORDANCE TABLES

Table 1 Final Terms of Reference - Concordance

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
1.0 INTRODUCTION		
Background	The purpose of this document is to identify for Cenovus FCCL Ltd., as operator for FCCL Partnership, (Cenovus), 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 Project – Phase H and Eastern Expansion (the Project). Cenovus is proposing to expand its in situ oil sands project in the Southern Athabasca Oil Sands region approximately 20 km southeast of Conklin in Townships 75 & 76, Ranges 4 through 6, west of the 4th Meridian. The Project is a 50/50 joint venture with ConocoPhillips Canada and will be operated by Cenovus. Steam Assisted Gravity Drainage (SAGD) technologies will be employed to recover bitumen resources from the McMurray Formation. Cenovus currently operates in an area located south of Christina Lake having recently submitted an amendment application that would bring the cumulative production capacity of the asset up to 238,800 bbl/day (37,969 m3/day). Resource delineation of additional assets has identified bitumen resource adjacent to the present Christina Lake operational area that would support the production of an additional estimated 50,000 bbl/day. Total approved production would increase to 288,800 bbl/day. The main infrastructure required to support the addition of the Phase H and Eastern Expansion area will include a central processing facility (to be built in a previously approved and cleared location) and associated shared infrastructure such as pipelines, roads, borrow areas and powerlines necessary to support approximately 190 new well pads. Each pad will have a full production life of approximately 25 years given the current technologies. Expansion associated with the Project will occur within areas previously assessed as part of the Christina Lake Phases E, F, and G Environmental Impact Assessment (EIA) submitted in 2009 and within an area to the east known as the Kirby East expansion area. The Project will employ the same well established Steam Assisted Gravity Drainage (SAGD) in situ resource recovery methods utilized at the existing CLTP operations to recover bitumen. The CLTP commercial project has operated since 2002. Through two previous EIA's and on-going environmental monitoring, significant information is known about the area. Cenovus plans to incorporate this accumulated knowledge into the Project EIA. These Terms of Reference recognize the location of the CLTP Phase H and Eastern expansion, the existing dataset and operating experience, and therefore have been tailored with the emphasis of the EIA and assessment of cumulative effects on specific areas of potential concern. For areas where there have been learnings from the existing/approved CLTP project, Cenovus intends on highlighting the adaptive environmental and regulatory management systems currently in place and the results of monitoring programs to improve the assessment of the potential impacts of the Project. The specific content of each environmental assessment area will be as identified in the Terms of Reference.	Volume 1, Section 1 Introduction

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
Scope of the Environmental Impact Assessment Report	The Proponent shall prepare and submit an EIA report that examines the environmental and socio-economic effects of the Project. The EIA report shall be prepared considering all applicable provincial and federal legislation, codes of practice, guidelines, standards, policies and directives. 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 the Proponent's application to the Energy Resources Conservation Board (ERCB).	Volumes 2 to 6
	An EIA report summary will also be included as part of the ERCB Application.	Volume 1, Section 13 Summary of Environmental Impact Assessment
Scope of the Environmental Impact Assessment Report (continued)	The Proponent 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 Environmental Impact Assessment 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 1 to 6
1.0 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION		
1.0 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION	[A] Describe the concerns and issues expressed by the public and the actions taken to address those concerns and issues, including how public input was incorporated into the Project development, impact mitigation and monitoring.	[A] Volume 1, Section 2 Public Consultation Volume 1, Section 2.5.7 Issues and Concerns
1.0 PUBLIC ENGAGEMENT AND ABORIGINAL CONSULTATION (continued)	[B] Describe the concerns and issues expressed by aboriginal communities and the actions taken to address those concerns and issues, including how aboriginal community input was incorporated into the Project, EIA development, mitigation, monitoring and reclamation. Describe consultation undertaken with aboriginal communities and groups with respect to traditional ecological knowledge, rights and traditional use of land and water.	[B] Volume 1, Section 2 Public Consultation; Volume 6, Section 2 Traditional Land Use
	[C] Discuss the Proponent's aboriginal consultation for the Project considering the approved First Nations Consultation Plan.	[C] Volume 1, Section 2.3 Aboriginal Consultation Volume 1, Section 2.4 Community-Based Consultation And Relationship Bodies
	[D] Describe plans to maintain the public engagement and aboriginal consultation process following completion of the EIA report 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.	[D] Volume 1, Section 2 Public Consultation

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.0 PROJECT DESCRIPTION		
2.1 Overview	[A] Provide a brief project description in sufficient detail to provide context for the EIA, including: a) proponent information; b) proposed extraction and bitumen processing technology; c) amount and source of energy required for the Project; d) water supply and disposal requirements, including process water and potable water requirements; e) proposed method to transport product to markets; and f) development plan and schedule.	[A] a) Volume 1, Section 1 Introduction b)Volume 1, Section 5.2 Reservoir and Recovery Process Abstract c) Volume 1, Appendix1-VIII Block Flow Diagrams, CPF Balances and Development Profile With ERCB Water Usage Formulas d) Volume 1, Section 8 Groundwater Management e) Volume 1, Section 7.4 Central Processing Facility Production Description f) Volume 1, Section 1.5 Project Schedule
	[B] 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] a) Volume 1, Figure 1.2-1 and 1.3-1 b), c) ,d) Volume 1, Appendix 1-VII Plot Plans and Equipment List e) Volume 1, Figure 1.2-1 and 1.3-1 f) Volume 1, Appendix 1-VII Plot Plans and Equipment List g) n/a h) Volume 1, Figure 1.2-1 and 1.3-1 i) Volume 6, Section 3 Resource Use Assessment j) Volume 1, Section 9.4 Waste Management

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.1 Overview (continued)	[C] Discuss the implications of a delay in proceeding with the Project, or any phase of the Project, or not going ahead with the Project.	[C] Volume 1, Section 1.4 Resource And Development Need Volume 1, Section 1.5 Project Schedule Volume 1, Section 11.3 Project Phasing and Timing
	[D] Describe the benefits of the project, including jobs created, local training, employment and business opportunities, and royalties and taxes generated that accrue to: a) Cenovus; b) local and regional communities, including Aboriginal communities; c) the local authority; d) Alberta; and e) Canada.	[D] Volume 6, Section 6.5 Economic Effects
	[E] Provide the adaptive management approach that will be implemented throughout the life of the Project. Include how monitoring, mitigation and evaluation were incorporated.	Volume 2, Appendix 2-VI Monitoring Programs
2.2 Relationship of the Phase H and Eastern Expansion to the existing/approved Christina Lake Developments (Phases A to G)	[A] Describe the history of the existing Christina Lake Development.	[A] Volume 1, Section 1.2 Christina Lake Thermal Project History
	[B] Provide maps showing the EIA study areas for Christina Lake and the proposed Project Area for the Phase H and Eastern Expansion. Discuss the implications of any overlaps in the mapped areas, including the confidence Cenovus has in the data and assessments from the previous Christina Lake developments as they apply to the Phase H and Eastern Expansion and the need for additional field studies to fill any gaps.	[B] Volume 2, Section 4.3, Figure 4.3-1
	[C] Describe for each EIA discipline the lessons learned from the planning, design, construction, operation, mitigation and monitoring of the existing Christina Lake Development.	[C] Volume 1, Section 3.2.2
	[D] Describe for each EIA discipline the lessons learned from the public engagement and aboriginal consultation process and the approvals process for the existing Christina Lake Development.	[D] Volume 1, Section 2.2, Stakeholder Engagement Volume 1, Section 2.5, Consultation
	[E] Describe how the lessons learned have been incorporated into the design of the Phase H and Eastern Expansion.	[E] Volume 1, Section 3.2.2

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.3 Constraints	[A] Discuss the process and criteria used to identify constraints to development, and how the Project has been designed to accommodate those constraints. Include the following: a) any applicable *Alberta Land Stewardship Act* Regional Plan; b) land use policies and resource management initiatives that pertain to the Project; c) how this project aligns with the Comprehensive Regional Infrastructure Sustainability Plan for the Athabasca Oil Sands Area. Include transportation, general infrastructure and consolidated project accommodations in the analysis; d) Aboriginal traditional land and water use; e) all known traplines; f) the environmental setting; g) cumulative environmental impacts in the region; h) cumulative social impacts in the region; i) results of Project-specific and regional monitoring; j) potential for new or additional technology to increase resource recovery at later times; k) potential for changes in the regulatory regime; and l) new protected areas through the Lower Athabasca Regional Plan administered by Alberta Tourism, Parks, and Recreation, such as the new Winefred Lake Provincial Recreation Area.	[A] a, b) Volume 6, Section 3 Resource Use Assessment c) Volume 6, Section 6.5.1 d, e) Volume 6, Section 2 Traditional Land Use Assessment f) Volume 1, Section 10.2 Surface Rights g) Volumes 2 to 6 h) Volume 6, Section 6 Socio-economic Assessment i) Volume 2, Appendix 2-VI Monitoring Programs Volume 1, Section 12 Regional Co-operation Volume 1, Section 14 Conservation and Reclamation Plan j) Volume 1, Section 11, Alternatives Considered k) Volume 1, Section 14 Conservation and Reclamation Plan l) Volume 6, Appendix 6-II Resource Use Baseline
	[B] Discuss the selection criteria used, options considered, and rationale for selecting: a) location of facilities and infrastructure (including linear infrastructure) with consideration of placements for future expansion(s); b) thermal energy and electric power required for the Project. c) water supply sources; d) wastewater treatment, management and disposal; e) air emission and air quality management; and f) waste disposal.	[B] Volume 1, Section 11, Alternatives Considered a, b) Volume 1, Section 7 Facilities c, d) Volume 1, Section 8, Groundwater Management e) Volume 3, Section 1 and Section 4 f) Volume 1, 9.4 Waste Management
	[C] Provide a list of facilities for which locations will be determined later. Discuss the selection criteria that will be used to determine the specific location of these facilities.	[C] n/a

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.4 Regional and Cooperative Efforts	[A] Discuss the Proponent's involvement in regional and cooperative efforts to address environmental and socio-economic issues associated with regional development.	[A] Volume 1, Section 12.2 Co-Operative Efforts
	[B] Describe opportunities for sharing infrastructure (e.g., access roads, utility corridors, water infrastructure) with other resource development stakeholders. Provide rationale where these opportunities will not be implemented.	[B] Volume 1, Section 12.2 Co-Operative Efforts Volume 1, Section 2.5.5 Other Formalized Groups
2.5 Transportation Infrastructure	[A] Prepare a Traffic Impact Assessment (TIA) as per Alberta Transportation's TIA Guideline (http://www.transportation.alberta.ca/613.htm). If there are any previous Traffic Impact Assessment studies that have been carried out for the Project or adjacent Projects using the same access, review and validate the findings and recommendations. a) describe the anticipated changes to highway traffic (e.g., type, volume) due to the Project; b) assess potential traffic impacts for all stages of the Project; and c) consider other existing and planned uses of the same highway.	[A] Volume 6, Section 6.6.7 Traffic and 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; and c) provide a proposed schedule for the work.	[B] Volume 6, Section 6.6.7 Traffic and Transportation
	[C] Indicate where Crown land dispositions may be needed for roads or infrastructure required for the Project.	[C] Volume 6, Section 6.6.7 Traffic and Transportation

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.6 Air Emissions Management	[A] Discuss the selection criteria used, options considered, and rationale for selecting control technologies to minimize air emission and ensure air quality management.	[A] Volume 1, Section 9.3 Greenhouse Gas Management; Volume 3, Section 1.3.2 Project Air Quality Management Initiatives
	[B] 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 and 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 detailed calculations; c) the intensity of greenhouse gas emissions per unit of bitumen produced; d) the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis; e) Cenovus' overall greenhouse gas management plans; f) amount and nature of Criteria Air Contaminants emissions; g) the amount and nature of acidifying emissions, probable deposition patterns and rates; h) emergency flaring scenarios (e.g., frequency and duration) and proposed measures to ensure flaring events are minimized; i) upset condition scenarios (e.g., frequency and duration) and proposed measures to ensure upset conditions are minimized; j) gas collection and conservation, and the applicability of vapour recovery technology; k) applicability of sulphur recovery, acid gas re-injection or flue gas desulphurization to reduce sulphur emissions; and l) fugitive emissions control technology to detect, measure and control emissions and odours from equipment leaks.	[B] (a) Volume 3, Section 1.7.2 Application Case; Volume 3, Appendix 3-I Emission Source Details; Volume 3, Section 1.7.9 Visible Emissions (b) Volume 3, Section 1.7.8 Key Question AQAC-6: What is the Contribution of the Project to Greenhouse Gas Emissions? Volume 3, Appendix 3-I Emission Source Details (c) Volume 3, Section 1.7.8.2 Greenhouse Gas Intensity (d) Volume 3, Section 1.7.8.1 Effects Analysis (e) Volume 3, Section 1.7.8.3 Approach to Managing Greenhouse Gases (f) Volume 3, Section 1.2.3 Emissions; Volume 3, Section 1.5.2 Baseline Case Emissions; Volume 3, Section 1.7.2 Application Case Emissions; Volume 3, Section 1.8.2 Planned Development Case Emissions; Volume 3, Appendix 3-I Emission Source Details (g) Volume 3, Section 1.5.2 Baseline Case Emissions; Volume 3, Section 1.7.2 Application Case Emissions;

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.6 Air Emissions Management (continued)		Volume 3, Section 1.7.4 Key Question AQAC-2: What Effects Could Existing and Approved Developments and the Project Have on the Deposition of Acid-Forming Compounds in the Region? Volume 3, Section 1.8.2 Planned Development Case Emissions; Volume 3, Section 1.8.4 Key Question 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? Volume 3, Appendix 3-I Emission Source Details (h) Volume 3, Appendix 3-II Upset Scenario (i) Volume 3, Appendix 3-II Upset Scenario (j) Volume 1, Section 7.10 Vapour Recovery System (k) Volume 3, Appendix 3-I Emission Source Details (l) Volume 3, Section 1.2.8.4 Air Emissions Criteria Volume 3, Section 1.3.2 Project Air Quality Management Initiatives

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.7 Water Management		
2.7.1 Water Supply	[A] Describe the water supply requirements for the entire Cenovus Christina Lake Project, and for the expansion specifically outline: a) the criteria used, options considered and rationale for selection of water supply sources(s); b) the expected water balance during all stages of the Project. Discuss assumptions made or methods chosen to arrive at the water balances; c) the process water, potable water, and non-potable water requirements and sources for construction (including but not limited to road construction, winter road construction, lease construction, production well drilling and dust suppression), camp(s) and plant site, 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; d) the location of sources/intakes and associated infrastructure (e.g., pipelines for water supply); e) the variability in the amount of water required on an annual and seasonal basis as the Project is implemented; f) describe contingency plans in the event of restrictions on the Projects water supply source (e.g., due to license conditions, source volume limitations, climate change or cumulative impact water deficits); g) the expected cumulative effects on water losses/gains resulting from the Project operations; h) annual and total freshwater use, both for the expansion and for the Project as a whole; i) potable water treatment systems for all stages of the Project; j) type and quantity of potable water treatment chemicals used; and k) 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.	[A] a) Volume 1, Section 8.3 Water Strategy and Well Locations b) Volume 1, Section 7.3; Volume 1, Appendix 1-VIII Block Flow Diagrams, CPF Balances and Development Profiles With ERCB Water Usage Formulas c) Volume 1, Section 8.3 Water Strategy and Well Locations d) Volume 1, Section 8.3 Water Strategy and Well Locations e) Volume 1, Section 8.3 Water Strategy and Well Locations f) Volume 1, Section 8.3 Water Strategy and Well Locations g) Volume 1, Section 7.3; Volume 1, Appendix 1-VIII Block Flow Diagrams, CPF Balances and Development Profiles With ERCB Water Usage Formulas h) Volume 1, Section 8.3 Water Strategy and Well Locations i) Volume 1, Section 8.3 Water Strategy and Well Locations j) Volume 1, Section 8.3 Water Strategy and Well Locations k) Volume 1, Section 8.3 Water Strategy and Well Locations Volume 4, Section 5.2 Hydrology

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.7.2 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] a) Volume 1, Section 8.2 Water Strategy and Well Locations b) n/a
	[B] Describe and map crossings of watercourses or waterbodies (including bridges, culverts and pipelines) required and provide example diagrams of each type of crossing.	[B] Volume 4, Section 3.4.3 Watercourse Crossing
	[C] Describe the placement of infrastructure (including processing facilities, well pads, roads and borrow pits) in relation to waterbodies and watercourses.	[C] Volume 1, Section 3.2
2.7.3 Wastewater Management	[A] Describe the wastewater management strategy, including: a) the criteria used, options considered and rationale for the selection of wastewater treatment and wastewater disposal; b) 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; c) the proposed disposal locations and methods for each wastewater stream; d) geologic formations for the disposal of wastewaters; e) design of facilities that will collect, treat, store and release wastewater streams; f) type and quantity of chemicals used in wastewater treatment; and g) sewage treatment and disposal.	[A] Volume 1, Section 9.4 Waste Management

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.8 Waste Management	[A] Discuss the selection criteria used, options considered, and rationale for waste disposal.	[A] Volume 1, Section 9.4 Waste Management
	[B] 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) describe how the disposal sites and sumps will be constructed; and c) describe plans for pollution prevention, waste minimization, recycling, and management to reduce waste quantities for all stages of the Project.	[B] Volume 1, Section 9.4 Waste Management
2.9 Conservation and Reclamation	[A] Provide a conceptual conservation and reclamation plan for the Project. Describe and map as applicable: a) current land use and capability and proposed post-development land use and capability; b) 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; c) constraints to reclamation such as timing of activities, availability of reclamation materials and influence of natural processes and cycles including natural disturbance regimes; d) a revegetation plan for the disturbed terrestrial, riparian and wetland areas; e) reclamation material salvage, storage areas and handling procedures; and f) existing and final reclaimed site drainage plans.	[A] a) Volume 1, Section 14.2 Existing Biophysical Environment; Volume 1, Section 14.10.1 Land Capability b) Volume 1, Section 14.8 Facility Decommissioning and Reclamation c) Volume 1, Section 14.9 Component-Specific Reclamation and Revegetation Plans d) Volume 1, Section 14.8.1 Revegetation e) Volume 1, Section 14.5 Surface Disturbance Plan (Sections 14.5.1 to 14.5.6) f) Volume 1, Section 14.5.6 Site Drainage; Volume 1, Section 14.7.2 Erosion Control; Volume 1, Section 14.7.3 Temporary Revegetation; Volume 1, Section 14.8.1 Revegetation

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
2.9 Conservation and Reclamation (continued)	[B] Discuss, from an ecological perspective, the expected timelines for establishment and recovery of vegetative communities and wildlife habitat, the expected success of establishment and recovery, and the expected differences in the resulting communities.	[B] Volume 1, Section 14.8 Facility Decommissioning and Reclamation
	[C] Describe how Cenovus considered the use of progressive reclamation in project design and reclamation planning.	[C] Volume 1, Section 14.12 Conservation and Reclamation Monitoring
	[D] Discuss Cenovus' involvement in any in-situ reclamation initiatives or reclamation working groups.	[D] Volume 1, Section 14.3 Objectives and Guidelines; Volume 1, Section 14.9.1 Well Pads and Water Wells; Volume 1, Section 14.11 Uncertainties and Constraints Related to Reclamation
	[E] Discuss uncertainties related to the conceptual reclamation plan.	[E] Volume 1, Section 14.11 Uncertainties and Constraints Related to Reclamation
3.0 ENVIRONMENTAL ASSESSMENT		
3.1 Air Quality, Climate and Noise		
3.1.1 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.	[A] (a) Volume 3, Appendix 3-IV Existing Air Quality and Meteorology (b) Volume 3, Appendix 3-IV Existing Air Quality and Meteorology

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.1.2 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; b) estimate ground-level concentrations of appropriate air quality parameters; c) discuss any expected changes to particulate deposition, nitrogen deposition or acidic deposition patterns; d) identify areas that are predicted to exceed Potential Acid Input (PAI) critical loading criteria; and e) discuss interactive effects that may occur resulting from co-exposure of a receptor to all emissions.	[A] Volume 3, Appendix 3-I Emission Source Details (a) Volume 3, Section 1.7 Application Case; (b) Volume 3, Section 1.5 Baseline Case; Volume 3, Section 1.7 Application Case; Volume 3, Section 1.8 Planned Development Case; c), (d) Volume 3, Section 1.5 Baseline Case; Volume 3, Section 1.7 Application Case; Volume 3, Section 1.8 Planned Development Case; Volume 3, Appendix 3-IV Existing Air Quality and Meteorology d) Volume 3, Section 4.4.2 Baseline Case; Volume 3, Section 4.4.3 Application Case; Volume 3, Section 4.4.4 Planned Development Case (e) Volume 3, Section 1.7 Application Case; Volume 3, Section 1.8 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 and discuss the potential impacts over the life of the Project.	[B] Volume 2, Appendix 2-V Climate Change Considerations
	[C] Summarize the results of the noise assessment conducted for the ERCB, and: a) identify the nearest receptor used in the assessment; and b) discuss the design, construction and operational factors to be incorporated into the Project to comply with the ERCB's Directive 38: Noise Control.	[C] Volume 3, Section 2

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.2 Hydrogeology		
3.2.1 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 disposal zones, and: a) present regional and Project Area geology to illustrate depth, thickness and spatial extent of lithology, stratigraphic units and structural features; and 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 resulting from 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.	[A] (a), (b) i) to iii) Volume 4, Section 4.1.1 Baseline Geology and Hydrogeology; Volume 4, Appendix 4 IV Hydrogeology Baseline iv) Volume 4, Section 4.1.2 Baseline Case Local and Regional Groundwater Users; Volume 4, Appendix 4 IV Hydrogeology Baseline v) to viii) Volume 4, Section 4.1.1 Baseline Geology and Hydrogeology; Volume 4, Appendix 4 IV Hydrogeology Baseline

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.2.2 Impact Assessment	[A] Describe Project components and activities that have the potential to affect groundwater resource quantity and quality at all stages of the Project.	[A] Volume 4, Section 5.1.1 Linkage Analysis
	[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 both groundwater and surface water quantity and quality; b) implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands; c) changes in groundwater quality, quantity and flow; 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 5.1.2 Effects Analysis of Groundwater Quantities, Levels and Flow Patterns; Volume 4, Section 5.1.3 Effects Analysis for Groundwater Quality (b) Volume 4, Section 5.4.1 Linkage Analysis (c) Volume 4, Section 5.1.2 Effects Analysis of Groundwater Quantities, Levels and Flow Patterns ; Volume 4, Section 5.1.3 Effects Analysis for Groundwater Quality (d) Volume 4, Section 5.1.2 Effects Analysis of Groundwater Quantities, Levels and Flow Patterns (e) Volume 4, Section 5.1.2 Effects Analysis of Groundwater Quantities, Levels and Flow Patterns (f) Volume 4, Section 5.1.2 Effects Analysis of Groundwater Quantities, Levels and Flow Patterns
3.3 Hydrology and Hydraulics		
3.3.1 Baseline Information	[A] Describe and map the surface hydrology in the Project Area. Include flow regime of streams in the project area.	[A], [B], [C] Volume 4, Section 4.2 Hydrology Volume 4, Appendix 4 V, Hydrology Baseline
	[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.	

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.3.2 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], [B] Volume 4, Section 5.2.3 Effects Analysis for Open-Water Areas, Flows and Water Levels
	[B] Describe the extent of hydrological changes, during all phases of the project, 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 the 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 resulting from the Project.	
3.3.2 Impact Assessment (continued)	[C] Discuss changes in sedimentation patterns in receiving waters resulting from the Project.	[B] (d), [C] Volume 4, Section 5.2.4 Effects Analysis for Geomorphic Conditions of Watercourses and the Concentrations of Suspended Sediments
	[D] Describe impacts on other surface water users resulting from the Project. Identify any potential water use conflicts.	[D] to [F] Volume 4, Section 5.2.3 Effects Analysis for Open-Water Areas, Flows and Water Levels
	[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] Describe residual effects of the Project on hydrology and Cenovus' plans to manage those effects.	[G] Volume 4, Section 5.2.4, Summary of Hydrology Assessment
3.4 Surface Water Quality		
3.4.1 Baseline information	[A] Describe the baseline water quality of watercourses and waterbodies.	[A] Volume 4, Section 4.3 Water Quality; Volume 4, Appendix 4 VII Water Quality Baseline
3.4.2 Impact Assessment	[A] Describe the potential impacts of the Project on surface water quality.	[A] Volume 3, Section 4.4.2 Baseline Case; Volume 3, Section 4.4.3 Application Case; Volume 3, Section 4.4.4 Planned Development Case Volume 4, Section 5.3.2 Effects Analysis for Water Quality

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.5 Aquatic Ecology		
3.5.1 Baseline Information	[A] Describe and map the fish, fish habitat and aquatic resources (e.g., aquatic and benthic invertebrates) of the lakes, rivers, ephemeral water bodies and other waters. Describe the species composition, distribution, relative abundance, movements and general life history parameters of fish resources. Also identify any species that are: a) listed as "at Risk, May be at Risk and Sensitive" in the General Status of Alberta Wild Species (Alberta Environment and Sustainable Resource Development); b) listed in Schedule 1 of the federal Species at Risk Act; c) listed as "at risk" by COSEWIC; and d) traditionally used species.	[A] Volume 4, Section 4.4 Fish and Fish Habitat; Volume 4, Appendix 4-VIII Fish and Fish Habitat Baseline
	[B] Describe and map existing critical or sensitive areas such as spawning, rearing, and over-wintering habitats, seasonal habitat use including migration and spawning routes. Provide a map of proposed drill paths overlain on surface hydrology.	[B] Volume 4, Appendix 4-VIII Fish and Fish Habitat Baseline; Volume 1, Section 5.6, Figure 5.6-1
	[C] Describe the current and potential use of the fish resources by aboriginal, sport or commercial fisheries.	[C] Volume 6, Appendix 6-I Traditional Land Use Baseline Report, Appendix 6-II Resource Use Baseline Report
3.5.2 Impact Assessment	[A] Describe and assess the potential impacts of the Project to fish, fish habitat, and other aquatic resources, considering: a) potential habitat loss and alteration; b) potential water quality and quantity changes; c) potential impacts on riparian areas that could affect aquatic biological resources and productivity; d) changes to benthic invertebrate communities that might affect food quality and availability for fish; e) potential increased fishing pressures in the region that could arise from the increased workforce and predicted regional population, and improved access from the Project. Characterize the current use of local and regional fisheries resources to support the assessment of potential changes in angling pressure; f) potential increased habitat fragmentation; g) potential acidification; h) potential groundwater-surface water interactions; i) potential for thermal plumes to interact with aquatic habitat;	[A] a) Volume 4, Section 5.4.2 Effects Analysis for Fish Habitat b) Volume 4, Section 5.4.2 Effects Analysis for Fish Habitat; Volume 4, Section 5.4.3 Effects Analysis for Fish Health c) Volume 4, Section 5.4.2 Effects Analysis for Fish Habitat d) Volume 4, Section 5.4.2 Effects Analysis for Fish Habitat e) Volume 4, Section 5.4. Effects Analysis for Fish Abundance; Volume 6, Section 3 Resource Use Assessment f) Volume 4, Section 5.4.2 Effects Analysis for Fish Habitat; Volume 4, Section 5.4.5 Effects Analysis for Fish and Fish Habitat Diversity

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.5.2 Impact Assessment (continued)	j) potential for ground heave and impacts to surface water flow and aquatic habitat; k) potential impacts to traditional use of aquatic resources; and l) potential entrapment and entrainment of fish at water intakes.	g) Volume 3, Section 4.4.2 Baseline Case; Volume 3, Section 4.4.3 Application Case; Volume 3, Section 4.4.4 Planned Development Case; Volume 4, Section 5.4.3 Effects Analysis for Fish Health; Volume 3, Section 4 Air Emissions Effects Assessment i) Volume 4, Section 5.4.1 Linkage Analysis j) Volume 4, Section 5.4.1 Linkage Analysis k) Volume 3, Section 4.4.2 Baseline Case; Volume 3, Section 4.4.3 Application Case; Volume 3, Section 4.4.4 Planned Development Case Volume 6, Section 2 Traditional Land Use l) Volume 4, Section 5.4.4 Effects Analysis for Fish Abundance
	[B] Identify the key aquatic indicators that the Proponent used to assess project impacts. Discuss the rationale for their selection.	[B] Volume 4, Section 2.7 Key Indicator 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.	[C] Volume 4, Section 5.4 Fish and Fish Habitat
3.6. Vegetation		
3.6.1 Baseline Information	[A] Describe and map the vegetation communities, wetlands, rare plants, old growth forests, and communities of limited distribution. Identify the occurrence, relative abundance and distribution and identify any species that are:	[A] Volume 5, Appendix 5-II, Section 4.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline
	a) listed as "at Risk, May be at Risk and Sensitive" in the General Status of Alberta Wild Species (Alberta Environment and Sustainable Resource Development);	a) Volume 5, Appendix 5-II, Section 6.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline; Volume 5, Appendix 5-III Wildlife and Wildlife Habitat Baseline
	b) listed in Schedule 1 of the federal *Species at Risk Act*;	b) Volume 5, Appendix 5-II Terrestrial Vegetation, Wetlands and Forest Resources Baseline; Volume 5, Appendix 5-IV Biodiversity Baseline; Volume 5, Appendix 5-III Wildlife and Wildlife Habitat Baseline

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.6.1 Baseline Information (continued)	c) listed as "at risk" by COSEWIC; and	c) Volume 5, Appendix 5-II, Section 6.2.3.8 Terrestrial Vegetation, Wetlands and Forest Resources Baseline; Volume 5, Appendix 5-IV Biodiversity Baseline; Volume 5, Appendix 5-III Wildlife and Wildlife Habitat Baseline
	d) traditionally used species.	d) Volume 5, Appendix 5-II, Section 6.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline
	[B] Describe and quantify the current extent of habitat fragmentation.	[B] Volume 5, Section 4.4 Biodiversity Volume 5, Section 6.4 Biodiversity Volume 5, Section 7.4 Biodiversity
3.6.2 Impact Assessment	[A] Identify key vegetation indicators to assess the Project impacts. Discuss the rationale for the indicator's selection.	[A] Volume 5, Appendix 5-II Section 2.7.2.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline
	[B] Describe and assess the potential impacts of the Project on vegetation communities including wetlands, rare plants, old growth forests and communities of limited distribution, considering:	[B] Volume 5, Section 6 Application Case;
	a) both temporary (include timeframe) and permanent impacts;	a) Volume 5, Appendix 5-II Section 6.2 Terrestrial Vegetation, Wetlands and Forest Reources Baseline
	b) the potential for introduction and colonization of weeds and non-native invasive species;	b) Volume 5, Section 6.1 Terrain and Soils; Volume 5, Appendix 5-II Section 6.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline
	c) potential increased fragmentation and loss of upland, riparian and wetland habitats; and	c) Volume 5, Appendix 5-II Section 6.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline; Volume 6, Section 2 Traditional Land Use Assessment; Volume 6, Section 3 Resource Use Assessment
	d) implications of vegetation changes for other environmental resources (e.g., terrestrial and aquatic habitat diversity and quantity, water quality and quantity, erosion potential).	d) Volume 3, Section 4.5 Application Case; Volume 5, Appendix 5-II Section 6.2 Terrestrial Vegetation, Wetlands and Forest Resources Baseline Volume 5, Section 6.4 Biodiversity Volume 5, Section 5 Linkage Analysis

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.7 Wildlife		
3.7.1 Baseline Information	[A] Describe and map the wildlife resources (amphibians, reptiles, birds, and terrestrial and aquatic mammals). Describe species relative abundance, distribution and their use and potential use of habitats. Also identify any species that are: a) listed as "at Risk, May be at Risk and Sensitive" in the General Status of Alberta Wild Species (Alberta Environment and Sustainable Resource Development); b) listed in Schedule 1 of the federal Species at Risk Act; c) listed as "at risk" by COSEWIC; and d) traditionally used species.	[A] Volume 5, Appendix 5-III Wildlife and Wildlife Habitat Baseline
	[B] Describe and map existing wildlife habitat and habitat disturbance (including exploration activities). Identify those habitat disturbances that are related to existing and approved projects.	[B] Volume 5, Appendix 5-III Wildlife and Wildlife Habitat Baseline; Volume 5, Appendix 5-V Wildlife Habitat Modelling; Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife
3.7.2 Impact Assessment	[A] Describe and assess the potential impacts of the Project to wildlife and wildlife habitats, considering: a) how the Project will affect wildlife relative abundance, habitat availability, mortality, movement patterns, and distribution for all stages of the Project;	a) Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife; Volume 5, Appendix 5-V Wildlife Habitat Modelling
	b) how Cenovus will meet the Woodland Caribou Policy for Alberta and the federal Recovery Strategy for the Woodland Caribou (Rangifer tarandus caribou), Boreal Population, in Canada;	b) Volume 5, Section 3.3 Wildlife Specific Mitigation; Volume 5, Section 3.4 Woodland Caribou Mitigation; Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife; Volume 5, Section 8.3 Wildlife; Volume 5, Appendix 5-V Wildlife Habitat Modelling
	c) how improved or altered access may affect wildlife;	c) Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife; Volume 5, Appendix 5-V Wildlife Habitat Modelling
	d) 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 predator-prey relationships;	d) Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife; Volume 5, Appendix 5-V Wildlife Habitat Modelling

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.7.2 Impact Assessment (continued)	e) potential effects on wildlife resulting from changes to air and water quality, including both acute and chronic effects to animal health; and	e) Volume 3, Section 4.4.2 Baseline Case Volume 3, Section 4.4.3 Application Case Volume 3, Section 4.4.4 Planned Development Case (e) Linkage Analysis (Volume 3, Section 3.2.4) Assessment Methods (Volume 3, Section 3.4.2) Wildlife Health Results (Volume 3, Section 3.4.4) Wildlife Health Conclusions (Volume 3, Section 3.4.6) Appendix 3-VIII Human and Wildlife Health Risk Assessment Methods, Section 5 Appendix 3-IX Exposure Assessment Model , Section 2 The effects of the Project on wildlife habitat are discussed in Volume 5 (Terrestrial Resources), Section 6.3 (Wildlife - Application Case).
	f) potential effects on wildlife from the Proponent's proposed and planned exploration, seismic and core hole activities, including monitoring/4D seismic.	f) Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife; Volume 5, Appendix 5-V Wildlife Habitat Modelling
	[B] Identify the key wildlife and habitat indicators used to assess Project impacts. Discuss the rationale for their selection.	[B] Volume 5, Section 2.7.2 Key Indicator Resources

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.8 Biodiversity		
3.8.1 Baseline Information	[A] Describe and map the existing biodiversity.	[A] Volume 5, Appendix 5-IV Biodiversity Baseline Volume 5, Section 4.4 Biodiversity
	[B] Identify the biodiversity metrics, biotic and abiotic indicators that are used to characterize the baseline biodiversity. Discuss the rationale for their selection.	[B] Volume 5, Appendix 5-IV Biodiversity Baseline Volume 5, Appendix 5-IV Biodiversity Baseline Attachments A and B Volume 5, Section 2.7.2.4 Volume 5, Section 4.4 Biodiversity
3.8.2 Impact Assessment	[A] Describe and assess the potential impacts of the Project to biodiversity considering:	Volume 5, Section 6.4 Biodiversity
	a) the biodiversity metrics, biotic and abiotic indicators selected;	a) Volume 5, Section 2.7.2.4 Volume 5, Section 4.4 Biodiversity
	b) the effects of fragmentation on biodiversity potential;	b) Volume 5, Section 6.4.2 Biodiversity Effects Analysis
	c) the contribution of the Project to any anticipated changes in regional biodiversity and the potential impact to local and regional ecosystems; and	c) Volume 5, Section 6.4 Biodiversity Volume 5, Section 7.4 Biodiversity
	d) effects during construction, operations and post-reclamation and the significance of these changes in a local and regional context.	d) Volume 5, Section 3 Mitigation Volume 5, Section 6.4 Biodiversity Volume 5, Section 7.4 Biodiversity
3.9 Terrain and Soils		
3.9.1 Baseline Information	[A] Describe and map the terrain and soils conditions in the Project Area.	[A] Volume 5, Section 6.1, Volume 5, Appendix 5-I Terrain and Soils Baseline, Christina Lake EFG Terrain and Soils Baseline (Cenovus 2009)
	[B] Describe and map soil types in the areas that are predicted in 3.1.2[A]d) to exceed Potential Acid Input (PAI) critical loading criteria.	[B] Volume 3, Section 4 Air Emissions Effects Assessment Volume 3, Section 4.4.2 Baseline Case

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.9.2 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, pipelines, 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
	b) discuss the relevance of any changes for the local and regional landscapes, biodiversity, productivity, ecological integrity, aesthetics and future use;	b) Volume 5, Section 5 Linkage Analysis Volume 6, Section 4, Visual Resources Assessment, Section 4.6
	c) identify the potential acidification impact on soils and discuss the significance of predicted impacts by acidifying emissions; and	c) Volume 3, Section 4.4.2 Baseline Case; Volume 3, Section 4.4.3 Application Case; Volume 3, Section 4.4.4 Planned Development Case
	d) describe potential sources of soil contamination.	d) Volume 5, Section 3.2 Operations (Mitigation), Section 5 Linkage Analysis Volume 1, Section 8.5 Waste Management
	[B] Discuss: a) the environmental effects of proposed drilling methods on the landscape and surficial and bedrock geology;	[B] a) Volume 5, Section 3.2 , Section 6.1 Volume 1, Section 4.4.4 Drilling and Completions Volume 1, Section 8 Environmental Management
	b) 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	b) Volume 5, Section 5, Section 6.1.2. Volume 1, Section 4.4.9 Surface Disturbance
	c) the potential impacts caused by the mulching and storage of woody debris considering, but not limited to vulnerability to fire, degradation of soil quality, increased footprint, etc.	c) Volume 5, Section 3.1, Volume 1, Section 14

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.10 Land Use and Management		
3.10.1 Baseline Information	[A] Describe and map the current land uses in the Project Area, including all Crown land and Crown Reservations (Holding Reservation, Protective Notation, Consultative Notation).	[A] Volume 6, Appendix 6-II Resource Use Baseline Report, Sections 3.1 Land Use Plans and Zoning and Section 3.5 Land Use Dispositions Volume 5, Appendix 5-II Terrestrial Vegetation, Wetlands and Forest Resources Baseline, Figure 14
	[B] Indicate where Crown land dispositions may be needed for roads or other infrastructure for the Project.	[B] Volume 6, Appendix 6-II Resource Use Baseline Report, Sections 3.1 Land Use Plans and Zoning and Section 3.5 Land Use Dispositions
	[C] Identify and map unique sites or special features in the Project Area and Local Study Area such as Parks and Protected Areas (current and proposed), 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, Section 3.8 Environmentally Important Areas
	[D] Describe and map land clearing activities, showing the timing of the activities.	[D] Volume 6, Appendix 6-II Resource Use Baseline Report, Section 3.1 Land Use Plans and Zoning
	[E] Describe the status of timber harvesting arrangements, including species and timing.	[E] Volume 6, Appendix 6-II Resource Use Baseline Report, Section 3.10 Forestry
	[F] Describe existing access control measures.	[F] Volume 6, Appendix 6-II Resource Use Baseline Report, Section 3.3 Access

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.10.2 Impact Assessment	[A] Identify the potential impacts of the Project on land uses, including: a) unique sites or special features; b) changes in public access arising from linear development, including secondary effects related to increased hunter, angler and other recreational access, and facilitated predator movement; c) aggregate reserves that may be located on land under the Proponent's control and reserves in the region; d) development and reclamation on commercial forest harvesting and fire management in the Project Area; e) the amount of commercial and non-commercial forest land base that will be disturbed by the Project, including the Timber Productivity Ratings for the Project Area. Compare the baseline and reclaimed percentages and distribution of all forested communities in the Project Area; f) how the Project impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area; g) how the Project impacts current and proposed parks and protected areas; h) anticipated changes (type and extent) to the topography, elevation and drainage patterns within the Project Area; and i) access control for public and regional recreational activities aboriginal land use and other land uses during and after development activities.	[A] a) Volume 6, Section 3.5.2.2 Mitigation, Section 3.5.2.3 Effects Analysis, and Section 3.6.2 Effects Analysis b) Volume 6, Section 3.5.3.2 Mitigation, Section 3.5.3.3 Effects Analysis, Section 3.6.3 Effects Analysis c) Volume 6, Section 3.5.3.1 Linkage Analysis and Section 3.5.3.2 Mitigation d) Volume 6, Section 3.5.3.2 Mitigation, Section 3.5.3.3 Effects Analysis, Section 3.6.3 Effects Analysis e) Volume 6, Section 3.5.3.2 Mitigation, Section 3.5.3.3 Effects Analysis, Section 3.6.3 Effects Analysis f) Volume 6, Section 3.5.3.2 Mitigation, Section 3.5.3.3 Effects Analysis, Section 3.6.3 Effects Analysis g) Volume 6, Section 3.5.2.2 Mitigation, Section 3.5.2.3 Effects Analysis and Section 3.6.2 Effects Analysis h) Volume 4, Section 5.2.3 Effects Analysis for Open-Water Areas, Flows and Water Levels; Volume 5, Section 5 Linkage Analysis, Section 6.1.2 Terrain Effects Analysis; Volume 1, Section 4.4.2.2 Surface Deformation Monitoring i) Volume 6, Section 3.5.3.2 Mitigation, Section 3.5.3.3 Effects Analysis, Section 3.6.3 Effects Analysis

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.10.2 Impact Assessment (continued)	[B] 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.	[B] Volume 1, Section 9.2.1 Emergency Management, Preparedness, and Response Processes, Appendix 1-XI Waste Management Chart and Wildfire Risk Assessment
4.0 HISTORIC RESOURCES		
4.0 HISTORIC RESOURCES	[A] Describe the Historic Resource Impact Assessment (HRIA) work done to date for the Project, and provide a schedule for any future work.	[A] Volume 6, Section 5.1 Introduction; Volume 6, Section 5.2.5.1 Historic Resources Impact Assessment Process Volume 6, Section 5.4.2 Regional Study Area
	[B] Describe the implications of the findings of the HRIA work on Project design and scheduling.	[B] Volume 6, Section 5.2.5 Assessment Methodology; Volume 6, Section 5.4.1 Local Study Area.
	[C] Describe any Project uncertainties arising from the need for future HRIA work.	[C] Volume 6, Section 5.2.5 Assessment Methodology; Volume 6, Section 5.4.1 Local Study Area.
4.1 Baseline Information	[A] Provide a brief overview of the regional historical resources setting including a discussion of the relevant archaeological, historic and palaeontological records.	[A] Volume 6, Section 5.4.2 Regional Study Area; Volume 6, Section 5.6.1.4 Palaeontological Resources
	[B] Describe and map known historic resources sites in the Project area, considering: a) site type and assigned Historic Resources Values (HRVs); and b) existing site specific Historical Resources Act requirements (if applicable).	[B] Volume 6, Figure 5.2-2
	[C] Provide an overview of previous Historical Resources Impact Assessments (HRIAs) that have been conducted within the Project Area, including: a) a description of the spatial extent of previous assessment relative to the Project Area, noting any assessment gap areas; and b) a summary of Historical Resources Act requirements and/or clearances that have been issued for the Project to date (if applicable).	[C] Volume 6, Section 5.1 Introduction (a) Volume 6, Section 5.2.5.1 Historic Resources Impact Assessment Process (b) Volume 6, Section 5.1 Introduction; Volume 6, Section 5.2.5.1 Historic Resources Impact Assessment Process
	[D] Identify locations within the Project Area that are likely to contain previously unrecorded historic resources. Thoroughly describe the methods used to identify these areas.	[D] Volume 6, Section 5.2.5.1 Historic Resources Impact Assessment Process

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
4.2 Impact Assessment	[A] Describe Project components and activities that have the potential to affect historic resources at all stages of the Project.	[A] Volume 6, Section 5.2.1 Definition of Historic Resources; Volume 6, Section 5.2.2 Temporal Considerations
	[B] Describe the nature and significance of the potential Project impacts on historical resources, considering: a) effects on historic resources site integrity; and b) implications for the interpretation of the archaeological, historic and palaeontological records.	[B] Volume 6, Section 5.2.5.1 Historic Resources Impact Assessment Process (a) Volume 6, Section 5.9 Conclusion (b) Volume 6, Section 5.3 Mitigation
5.0 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE		
5.0 TRADITIONAL ECOLOGICAL KNOWLEDGE AND LAND USE	[A] Provide: a) a map and description of traditional land use areas including fishing, hunting, trapping and nutritional, medicinal or cultural plant harvesting by affected aboriginal peoples (if the aboriginal community or group is willing to have these locations disclosed); b) a map of cabin sites, spiritual sites, cultural sites, graves and other traditional use sites considered historic resources under the *Historical Resources Act* (if the aboriginal community or group is willing to have these locations disclosed), as well as traditional trails and resource activity patterns; and c) a discussion of: i) the availability of vegetation, fish and wildlife species for food, traditional, medicinal and cultural purposes in the identified traditional land use areas considering all Project related impacts, ii) access to traditional lands in the Project Area during all stages of the Project, and iii) aboriginal views on land reclamation.	[A] a) Traditional Land Use Baseline Report (Volume 6, Appendix 6-I) b) Traditional Land Use Baseline Report (Volume 6, Appendix 6-I) c) Traditional Land Use Assessment (Volume 6, Section 2.8)
	[B] Describe how TEK and TLU information was incorporated into the Project, EIA development, the conservation and reclamation plan, monitoring and mitigation.	[B] Volume 1, Section 2 Public Consultation; Volume 1, Section 14 Conservation and Reclamation Plan
	[C] Determine the impacts of the Project on traditional, medicinal and cultural purposes and identify possible mitigation strategies.	[C] Traditional Land Use Assessment (Volume 6, Section 2.4)

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
6.0 PUBLIC HEALTH AND SAFETY		
6.1 Public Health	[A] Describe those aspects of the Project that may have implications for public health or the delivery of regional health services. Determine quantitatively whether there may be implications for public health arising from the Project.	[A] Linkage Analysis (Volume 3, Section 3.2.4) Assessment Methods (Volume 3, Section 3.3.2) Effects of Short-Term (Acute) Exposure to Emissions on Human Health - Application Case (Volume 3, Section 3.3.4.1) Effects of Long-Term (Chronic) Exposure to Emissions on Human Health - Application Case (Volume 3, Section 3.3.4.2) Effects of Exposure to PM2.5 Emissions on Human Health - Application Case (Volume 3, Section 3.3.4.3) Appendix 3-VIII Human and Wildlife Risk Assessment Methods, Sections 2 to 4 Appendix 3-IX Exposure Assessment, Section 1
	[B] Document any health concerns raised by stakeholders during consultation on the Project.	[B and C] Consultation and Assessment Focus (Volume 3, Section 3.2.5)

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
3.7.2 Impact Assessment (continued)	[C] 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. Describe how you plan to mitigate these concerns.	[B and C] Consultation and Assessment Focus (Volume 3, Section 3.2.5) [C] Effects of Short-Term (Acute) Exposure to Emissions on Human Health - Application Case (Volume 3, Section 3.3.4.1) Effects of Long-Term (Chronic) Exposure to Emissions on Human Health - Application Case (Volume 3, Section 3.3.4.2) Effects of Exposure to PM2.5 Emissions on Human Health - Application Case (Volume 3, Section 3.3.4.3) The aspects of the Project that may have implications for the delivery of regional health services are discussed in Volume 6 (Social Aspects), Section 6.6.4 (Health Services).
	[D] Describe the potential health impacts resulting from higher regional traffic volumes and the increased risk of accidental leaks and spills.	Volume 6, Section 6.6.7 Traffic and Transportation
6.2 Public Safety	[A] 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 the Proponent'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; and e) describe the potential safety impacts resulting from higher regional traffic volumes.	a) Volume 1, Section 9.2 Environment, Health and Safety Management b) Volume 1, Section 2.5 Consultation c) Volume 1, Section 9.2 Environment, Health and Safety Management d) Volume 1, Section 9.2 Environment, Health and Safety Management e) Volume 6, Section 6.6.7 Traffic and Transportation
7.0 SOCIO-ECONOMIC ASSESSMENT		
7.1 Baseline Information	[A] Describe the existing socio-economic conditions in the region and in the communities in the region.	[A] Volume 6, Appendix 6-III

Table 2 Final Terms of Reference - 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) workforce requirements for the Project, including a description of when peak activity periods will occur; c) planned accommodations for the workforce for all stages of the Project; d) Cenovus' policies and programs regarding the use of local, regional and Alberta goods and services; e) the project schedule; and f) the overall engineering and contracting plan for the Project.	[B] a) Volume 6, Appendix 6-III; Section 6.6.1 b) Volume 6, Section 6.6.1 c) Volume 6, Section 6.4.3 d) Volume 6, Section 6.5.1 e) Volume 1 Section 1.5; Volume 6, Section 6.5.1 f) Volume 1 Section 3, Section 4, Section 5, Section 6 and Section 7 Volume 6 Section 6.4.2; Section 6.5.1
7.2 Impact Assessment	[A] Describe the effects of construction and operation of the Project on: a) housing; b) availability and quality of health care services; c) local and regional infrastructure and community services; d) recreational activities; e) parks and protected areas; f) hunting, fishing, trapping and gathering; and g) First Nations and Métis (e.g., traditional land use and social and cultural implications).	[A] a) Volume 6, Section 6.6.2 b) Volume 6, Section 6.6.4 c) Volume 6, Sections 6.6.3; 6.6.5; 6.6.6. 6.6.7, 6.6.8 d) Volume 6, Section 6.6.9 e) Volume 6, Section 3.5.2 f) Volume 6, Section 3.5.5 Volume 6, Section 2 g) Volume 6, Section 2
7.2 Impact Assessment (continued)	[B] Discuss how Cenovus is utilizing existing camp infrastructure for the Project or how workers for the Project will be housed. With the use of an existing camp, discuss the camp location, the number of workers from this Project that will use the camp and the percentage of occupancy this Project will utilize.	[B] Volume 6, Section 6.4.3
	[C] Describe the need for additional Crown land to manage the effects in [A] and [B].	[C] Volume 6, Section 6.6.2
	[D] Discuss opportunities to work with First Nation and Métis communities and groups, other local residents and businesses regarding employment, training needs and other economic development opportunities arising from the Project.	[D] Volume 6, Sections 6.4.2; 6.4.4
	[E] Provide the 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.	[E] Volume 6, Section 6.5.1

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
8.0 MITIGATION MEASURES		
8.0 MITIGATION MEASURES	[A] Discuss mitigation measures to avoid, minimize or eliminate the potential impacts for all stages of the Project.	[A] Volume 4, Section 3 Volume 5, Section 3 Volume 6, Section 3.5.3.2 Mitigation, and Section 3.5.2.2 Mitigation
	[B] Identify mitigation objectives and those mitigation measures that will be implemented for each associated impact and provide rationale for their selection, including a discussion on the effectiveness of the proposed mitigation.	[B] Volume 1, Section 14 Conservation and Reclamation Plan Volume 4, Section 5.1 Hydrogeology Volume 4, Section 5.2 Hydrology Volume 4, Section 5.3 Water Quality Volume 4, Section 5.4 Fish and Fish Habitat Volume 5, Section 3.4 and 3.5 Volume 5, Section 6.3 Wildlife; Volume 5, Section 7.3 Wildlife Volume 5, Section 3 Volume 5, Section 4.4.3 Landscape-Level Biodiversity; Volume 6, Section 3.5.3.2 Mitigation, and Section 3.5.2.2 Mitigation
9.0 RESIDUAL IMPACTS		
9.0 RESIDUAL IMPACTS	[A] Describe the residual impacts of the Project following implementation of the Proponent's mitigation measures and the Proponent's plans to manage those residual impacts.	[A] Volume 4, Section 5.1.4 Summary of Application Case Hydrogeology Assessment Volume 4, Section 5.2.5 Summary of Hydrology Assessment Volume 4, Section 5.3.3 Summary of Water Quality Assessment Volume 4, Section 5.4.6 Summary of Fish and Fish Habitat Assessment Volume 5, Section 6.2.8 Terrestrial Vegetation, Wetlands and Forest Resources

Table 2 Final Terms of Reference - Concordance (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
10.0 MONITORING		
10.0 MONITORING	[A] Describe Cenovus' current monitoring programs for Christina Lake Thermal Project.	[A] Volume 1, Section 14.12; Volume 2, Appendix 2-VI Monitoring Programs; Volume 4, Section 7; Volume 5, Sections 3.4, 3.5, 8.2, 8.3;Volume 6, Section 3.5.2.5 Monitoring, Section 3.5.3.5 Monitoring,
	[B] Describe any new monitoring that will be required as a result of this project, including: a) how the monitoring programs will assess any project impacts and measure the effectiveness of mitigation plans. Discuss how the Proponent will address any Project impacts identified through the monitoring program; and b) how the results of monitoring programs and publicly available monitoring information will be integrated with the Proponent's environmental management system and how it will be used to manage environmental effects, confirm performance of mitigation measures, and improve environmental protection strategies.	[B] Volume 1, Section 14.12; Volume 4, Section 7; Volume 5, Sections 3.4, 3.5, 8.2, 8.3
	[C] Discuss the Proponent's current and proposed monitoring programs, including: a) how the monitoring programs will assess any project impacts and measure the effectiveness of mitigation plans. Discuss how the Proponent will address any Project impacts identified through the monitoring program; b) how the Proponent will contribute to current and proposed regional monitoring programs; c) monitoring performed in conjunction with other stakeholders, including aboriginal communities and groups; d) new monitoring initiatives that may be required as a result of the Project; e) regional monitoring that will be undertaken to assist in managing environmental effects and improve environmental protection strategies; f) how monitoring data will be disseminated to the public, aboriginal communities or other interested parties; and g) how the results of monitoring programs and publicly available monitoring information will be integrated with the Proponent's environmental management system and how it will be used to manage environmental effects, confirm performance of mitigation measures, and improve environmental protection strategies.	[C] Volume 1, Section 14.12; Volume 3, Section 4.6 Monitoring; Volume 4, Section 7; Volume 5, Sections 3.4, 3.5, 8.2 and 8.3 Wildlife; Volume 5, Section 8.4 Biodiversity

APPENDIX 2-III

COMMON AND SCIENTIFIC NAMES

Scientific Name	Common Name
Vegetation	
Tree	
Abies balsamea	balsam fir
Alnus incana ssp. *Tenuifolia*	river alder
Alnus sp.	alder species
Amelanchier alnifolia	saskatoon
Betula occidentalis	water birch
Betula papyrifera	white birch
Betula sp.	bog/dwarf birch
Larix laricina	tamarack
Picea glauca	white spruce
Picea mariana	black spruce
Pinus banksiana	jack pine
Populus balsamifera	balsam poplar
Populus tremuloides	aspen
Rhamnus sp.	-
Salix arbusculoides	shrubby willow
Salix bebbiana	beaked willow
Salix lucida	shining willow
Salix scouleriana	Scouler's willow
Salix serissima	autumn willow
Salix sp.	willow species
Shrub	
Alnus incana	gray alder
Alnus viridis	green alder
Alnus viridis ssp. *crispa*	green alder
Andromeda polifolia	bog rosemary
Arctostaphylos rubra	alpine bearberry
Arctostaphylos uva-ursi	bearberry
Betula glandulosa	bog birch
Betula pumila	dwarf birch
Chamaedaphne calyculata	leatherleaf
Cornus stolonifera	red-osier dogwood
Ledum groenlandicum	Labrador tea
Linnaea borealis	twinflower
Lonicera caerulea	fly honeysuckle
Lonicera involucrata	bracted honeysuckle
Lonicera sp.	honeysuckle species
Oxycoccus microcarpus	small bog cranberry
Rhamnus alnifolia	alder-leaved buckthorn
Ribes americanum	wild black currant
Ribes glandulosum	skunk currant
Ribes hudsonianum	northern black currant
Ribes lacustre	bristly black currant
Ribes oxyacanthoides	northern gooseberry
Ribes sp.	currant species
Ribes triste	wild red currant
Rosa acicularis	prickly rose
Rosa woodsii	common wild rose
Rubus idaeus	wild red raspberry
Salix barclayi	Barclay's willow

Scientific Name	Common Name
Salix candida	hoary willow
Salix maccalliana	velvet-fruited willow
Salix myrtillifolia	myrtle-leaved willow
Salix pedicellaris	bog willow
Salix planifolia	flat-leaved willow
Salix pyrifolia	balsam willow
Shepherdia canadensis	Canada buffaloberry
Symphoricarpos albus	snowberry
Vaccinium caespitosum	dwarf bilberry
Vaccinium myrtilloides	blueberry
Vaccinium myrtillus	low bilberry
Vaccinium vitis-idaea	bog cranberry
Viburnum edule	low-bush cranberry
Forb	
Achillea millefolium	common yarrow
Actaea rubra	red and white baneberry
Amerorchis rotundifolia	round-leaved orchid
Aquilegia sp.	columbine species
Aralia nudicaulis	wild sarsaparilla
Aster ciliolatus	Lindley's aster
Aster conspicuus	showy aster
Aster puniceus	purple-stemmed aster
Aster sp.	aster species
Athyrium filix-femina	lady fern
Botrychium lunaria	moonwort
Botrychium virginianum	Virginia grape fern
Caltha natans	floating marsh-marigold
Caltha palustris	marsh-marigold
Campanula rotundifolia	harebell
Cardamine pratensis	meadow bitter cress
Cerastium nutans	long-stalked mouse-ear chickweed
Ceratophyllum demersum	hornwort
Chrysosplenium iowense	golden saxifrage
Chrysosplenium tetrandrum	green saxifrage
Cicuta bulbifera	bulb-bearing water-hemlock
Cicuta maculata	water-hemlock
Cicuta virosa	narrow-leaved water-hemlock
Cirsium arvense	creeping thistle
Coeloglossum viride	bracted bog orchid
Coptis trifolia	goldthread
Corallorhiza maculata	spotted coralroot
Corallorhiza trifida	pale coralroot
Cornus canadensis	bunchberry
Diphasiastrum complanatum	ground-cedar
Drosera rotundifolia	round-leaved sundew
Dryopteris carthusiana	narrow spinulose shield fern
Epilobium angustifolium	fireweed
Epilobium palustre	marsh willowherb
Epilobium sp.	willowherb species
Equisetum arvense	common horsetail
Equisetum fluviatile	swamp horsetail

Scientific Name	Common Name
Equisetum hyemale	scouring-rush
Equisetum pratense	meadow horsetail
Equisetum scirpoides	dwarf scouring-rush
Equisetum sp.	horsetail species
Equisetum sylvaticum	woodland horsetail
Equisetum variegatum ssp. *variegatum*	variegated scouring rush
Erigeron sp.	fleabane species 1
Fragaria vesca	woodland strawberry
Fragaria virginiana	wild strawberry
Galium boreale	northern bedstraw
Galium labradoricum	Labrador bedstraw
Galium sp.	bedstraw species
Galium trifidum	small bedstraw
Galium triflorum	sweet-scented bedstraw
Geocaulon lividum	northern bastard toadflax
Geum aleppicum	yellow avens
Geum macrophyllum	large-leaved yellow avens
Geum sp.	avens species
Gymnocarpium dryopteris	oak fern
Hippuris vulgaris	common mare's-tail
Impatiens capensis	spotted touch-me-not
Lathyrus ochroleucus	cream-colored vetchling
Lathyrus venosus	purple peavine
Lilium philadelphicum	western wood lily
Liparis loeselii	Loesel's twayblade
Lycopodium annotinum	stiff club-moss
Lycopodium obscurum	ground-pine
Lysimachia thyrsiflora	tufted loosestrife
Maianthemum canadense	wild lily-of-the-valley
Malaxis monophylla	white adder's-mouth
Melampyrum lineare	cow-wheat
Melilotus alba	white sweet-clover
Mentha arvensis	wild mint
Menyanthes trifoliata	buck-bean
Mertensia paniculata	tall lungwort
Mitella nuda	bishop's-cap
Moneses uniflora	one-flowered wintergreen
Orthilia secunda	one-sided wintergreen
Parnassia palustris	northern grass-of-parnassus
Pedicularis groenlandica	elephant's-head
Pedicularis labradorica	Labrador lousewort
Pedicularis parviflora	swamp lousewort
Petasites frigidus	Arctic sweet coltsfoot
Petasites frigidus var. *palmatus*	palmate-leaved coltsfoot
Petasites frigidus var. *sagittatus*	arrow-leaved coltsfoot
Platanthera hyperborea	northern green bog orchid
Platanthera obtusata	blunt-leaved bog orchid
Platanthera orbiculata	round-leaved bog orchid
Potentilla norvegica	rough cinquefoil
Potentilla palustris	marsh cinquefoil
Potentilla tridentata	three-toothed cinquefoil

Scientific Name	Common Name
Pyrola asarifolia	common pink wintergreen
Pyrola chlorantha	greenish-flowered wintergreen
Pyrola sp.	wintergreen species
Ranunculus gelidus	Gray's buttercup
Ranunculus gmelinii	yellow water crowfoot
Ranunculus lapponicus	Lapland buttercup
Rhinanthus minor	yellow rattle
Rubus arcticus	dwarf raspberry
Rubus chamaemorus	cloudberry
Rubus pubescens	dewberry
Rumex crispus	curled dock
Rumex occidentalis	western dock
Rumex sp.	dock species
Sarracenia purpurea	pitcher-plant
Scheuchzeria palustris	scheuchzeria
Scutellaria galericulata	marsh skullcap
Sium suave	water parsnip
Smilacina racemosa	false Solomon's-seal
Smilacina trifolia	three-leaved Solomon's-seal
Sparganium angustifolium	narrow-leaved bur-reed
Spiranthes romanzoffiana	hooded ladies'-tresses
Stellaria longifolia	long-leaved chickweed
Stellaria longipes	long-stalked chickweed
Stellaria sp.	starwort species
Tanacetum vulgare	common tansy
Taraxacum officinale	common dandelion
Thalictrum sparsiflorum	flat-fruited meadow rue
Thalictrum venulosum	veiny meadow rue
Thermopsis rhombifolia	golden bean
Tofieldia glutinosa	sticky false asphodel
Trientalis borealis	northern starflower
Trifolium hybridum	alsike clover
Triglochin maritima	seaside arrow-grass
Typha latifolia	cattail
Urtica dioica	common nettle
Utricularia intermedia	flat-leaved bladderwort
Utricularia vulgaris	common bladderwort
Veronica scutellata	marsh speedwell
Vicia americana	wild vetch
Viola adunca	early blue violet
Viola canadensis	western Canada violet
Viola renifolia	kidney-leaved violet
Viola sp.	violet species
Graminoid	
Agropyron sp.	wheat grass species
Agrostis scabra	rough hair grass
Agrostis stolonifera	redtop
Alopecurus aequalis	short-awned foxtail
Calamagrostis canadensis	bluejoint
Calamagrostis sp.	calamagrostis species
Carex aenea	silvery-flowered sedge

Scientific Name	Common Name
Carex aquatilis	water sedge
Carex aurea	golden sedge
Carex bebbii	Bebb's sedge
Carex brunnescens	brownish sedge
Carex canescens	short sedge
Carex capillaris	hair-like sedge
Carex chordorrhiza	prostrate sedge
Carex deflexa	bent sedge
Carex deweyana	Dewey's sedge
Carex diandra	two-stamened sedge
Carex disperma	two-seeded sedge
Carex gynocrates	northern bog sedge
Carex interior	inland sedge
Carex lasiocarpa	hairy-fruited sedge
Carex leptalea	bristle-stalked sedge
Carex limosa	mud sedge
Carex norvegica	Norway sedge
Carex pauciflora	few-flowered sedge
Carex paupercula	bog sedge
Carex peckii	Peck's sedge
Carex prairea	prairie sedge
Carex praticola	meadow sedge
Carex sartwellii	Sartwell's sedge
Carex sp.	sedge species
Carex tenuiflora	thin-flowered sedge
Carex trisperma	three-seeded sedge
Carex utriculata	small bottle sedge
Carex vaginata	sheathed sedge
Carex viridula	green sedge
Eleocharis palustris	creeping spike-rush
Elymus sp.	wildrye species
Eriophorum angustifolium	tall cotton-grass
Eriophorum gracile	slender cotton grass
Eriophorum vaginatum	sheathed cotton grass
Glyceria grandis	common tall manna grass
Glyceria sp.	manna grass species
Glyceria striata	fowl manna grass
Hierochloe hirta	northern sweetgrass
Hordeum jubatum	foxtail barley
Leymus innovatus	hairy wild rye
Luzula parviflora	small-flowered wood-rush
Luzula sp.	wood-rush species
Oryzopsis pungens	northern rice grass
Phalaris arundinacea	reed canary grass
Poa palustris	fowl bluegrass
Scirpus hudsonianus	Hudson Bay bulrush
Scirpus microcarpus	small-fruited bulrush
Bryophyte	
Agrocybe praecox	spring agrocybe
Anastrophyllum helleranum	liverwort
Aulacomnium palustre	tufted moss

Scientific Name	Common Name
Brachythecium mildeanum	brachythecium moss
Brachythecium sp.	brachythecium moss species
Bryum pseudotriquetrum	common green bryum moss
Bryum sp.	bryum moss species
Calliergon cordifolium	calliergon moss
Calliergon giganteum	giant water moss
Calliergon richardsonii	Richardson's water moss
Calliergon stramineum	straw-coloured water moss
Campylium hispidulum	hispid campylium moss
Cephaloziella sp.	cephaloziella liverwort species
Ceratodon purpureus	purple horn-toothed moss
Climacium dendroides	common tree moss
Conocephalum conicum	snake liverwort
Cratoneuron filicinum	fern leaved hook moss
Dicranum flagellare	whip fork moss
Dicranum fragilifolium	cushion moss
Dicranum fuscescens	fuscous moss
Dicranum polysetum	wavy dicranum
Dicranum scoparium	broom moss
Dicranum sp.	dicranum moss species
Dicranum undulatum	wavy dicranum
Drepanocladus aduncus	brown moss
Drepanocladus sp.	brown moss species
Eurhynchium pulchellum	eurhynchium moss
Hamatocaulis lapponicus	Lapland moss
Hamatocaulis vernicosus	brown moss
Helodium blandowii	Blandlow's feather moss
Hylocomium splendens	stair-step moss
Hypnum lindbergii	Lindberg's hypnum moss
Hypnum sp.	hypnum moss species
Jamesoniella autumnalis	liverwort
Leiomylia anomala	liverwort
Leptodictyum riparium	stringy moss
Limprichtia revolvens	brown moss
Lophocolea heterophylla	liverwort
Marchantia polymorpha	liverwort
Meesia triquetra	meesia moss
Mnium sp.	mnium species
Orthothecium strictum	orthothecium moss
Orthotrichum obtusifolium	obtuseleaf aspen moss
Orthotrichum speciosum	lanceolateleaf rock moss
Plagiomnium cuspidatum	toothed plagiomnium moss
Plagiomnium ellipticum	elliptic plagiomnium moss
Pleurozium schreberi	Schreber's moss
Polytrichum commune	common hair-cap
Polytrichum juniperinum	juniper hair-cap
Polytrichum sp.	hair-cap species
Polytrichum strictum	slender hair-cap
Porella sp.	-
Ptilidium ciliare	liverwort
Ptilidium pulcherrimum	liverwort

Scientific Name	Common Name
Ptilium crista-castrensis	knight's plume moss
Pylaisiella polyantha	pylaisiella moss
Rhizomnium pseudopunctatum	rhizomnium moss
Sanionia uncinata	brown moss
Sphagnum angustifolium	peat moss
Sphagnum capillifolium	acute-leaved peat moss
Sphagnum fuscum	rusty peat moss
Sphagnum girgensohnii	Girgensohn's moss
Sphagnum magellanicum	midway peat moss
Sphagnum sp.	peat moss
Sphagnum squarrosum	squarrose peat moss
Sphagnum warnstorfii	Warnstorf's peat moss
Sphagnum wulfianum	peat moss
Splachnum rubrum	red collar moss
Splachnum sp.	splachnum species
Tetraphis pellucida	tetraphis moss
Tetraplodon angustatus	narrow-leaved splachnum
Tetraplodon sp.	nitrogen moss species
Thuidium recognitum	thuidium moss
Tomentypnum nitens	golden moss
Warnstorfia fluitans	water hook moss
Lichen	
Arthonia edgewoodensis	lichen
Arthonia patellulata	dot lichen
Bryoria furcellata	horsehair
Bryoria fuscescens	speckled horsehair
Bryoria lanestris	old man's beard
Bryoria simplicior	old man's beard
Buellia griseovirens	button lichen
Buellia punctata	button lichen
Caloplaca ahtii	lichen
Candelariella vitellina	common goldspeck lichen
Cetraria ericetorum	Iceland lichen
Cetraria sepincola	tuckermannopsis lichen
Cladina arbuscula	reindeer lichen
Cladina mitis	green reindeer lichen
Cladina rangiferina	grey reindeer lichen
Cladina stellaris	northern reindeer lichen
Cladina stygia	black-footed reindeer lichen
Cladonia albonigra	-
Cladonia borealis	red pixie-cup
Cladonia cenotea	powdered funnel lichen
Cladonia chlorophaea	mealy pixie-cup
Cladonia coniocraea	cup lichen
Cladonia cornuta	bighorn cladonia
Cladonia crispata	organ-pipe lichen
Cladonia cristatella	British soldiers
Cladonia deformis	lesser sulphur-cup
Cladonia fimbriata	trumpet lichen
Cladonia gracilis	smooth cladonia
Cladonia gracilis ssp. *turbinata*	cup lichen

Scientific Name	Common Name
Cladonia macilenta	lipstick powderhorn
Cladonia sp.	cup lichen species
Evernia mesomorpha	boreal oakmoss lichen
Hypogymnia physodes	monk's-hood lichen
Icmadophila ericetorum	spraypaint
Imshaugia placorodia	American starburst lichen
Lecanora boligera	rim-lichen
Lecanora hagenii	Hagen's rim lichen
Lecanora impudens	rim lichen
Lecanora pulicaris	rim-lichen
Lecidea leprarioides	tile lichen
Melanelia septentrionalis	northern camoflage lichen
Melanelia subaurifera	abraded camoflage lichen
Micarea prasina	dot lichen
Mycoglaena myricae	Mycoglaena
Ochrolechia androgyna	powdery saucer lichen
Parmelia sulcata	hammered shield moss
Parmeliopsis ambigua	green starburst lichen
Parmeliopsis hyperopta	gray starburst lichen
Peltigera aphthosa	studded leather lichen
Peltigera canina	dog lichen
Peltigera neopolydactyla	carpet pelt
Peltigera ponojensis	felt lichen
Peltigera sp.	felt lichen species
Phaeophyscia hirsuta	hairy wreath lichen
Phaeophyscia orbicularis	wreath lichen
Physcia adscendens	hooded rosette lichen
Physcia stellaris	star rosette lichen
Pycnora elachista ined.	lichen
Pyrrhospora cinnabarina	northern measle lichen
Ramalina dilacerata	punctured ramalina
Rinodina septentrionalis	rinodina lichen
Scoliciosporum perpusillum	scoliciosporum lichen
Scoliciosporum umbrinum	-
Tuckermannopsis americana	fringed wrinkle-lichen
Tuckermannopsis platyphylla	-
Usnea cavernosa	old man's beard
Usnea fulvoreagens	beard lichen
Usnea glabrata	old man's beard
Usnea hirta	shaggy beard lichen
Usnea lapponica	powdered beard lichen
Usnea scabrata	straw beard lichen
Usnea subfloridana	beard lichen
Usnea substerilis	beard lichen
Vulpicida pinastri	powdered sunshine lichen
Wildlife	
Mammals	
-	deer species
Alces alces	moose
Castor canadensis	beaver
Canis latrans	coyote

Scientific Name	Common Name
Canis lupus	grey wolf
Lynx canadensis	Canada lynx
Martes pennanti	fisher
Martes species	fisher/marten
Mustela species	weasel spp.
Odocoileus hemionus	mule deer
Odocoileus virginianus	white-tailed deer
Rangifer tarandus	woodland caribou
Ursus americanus	black bear
Vulpes vulpes	red fox
Amphibians/Reptiles	
Bufo boreas	western toad
Pseudacris triseriata	boreal chorus frog
Rana sylvatica	wood frog
Birds	
-	red-necked grebe
Ammodramus leconteii	Le Conte's sparrow
Ardea herodias	great blue heron
Bubo virginianus	great horned owl
Catharus guttatus	hermit thrush
Catharus ustulatus	Swainson's thrush
Chlidonias niger	black tern
Coturnicops noveboracensis	yellow rail
Dendroica coronata	yellow rumped warbler
Dryocopus pileatus	pileated woodpecker
Empidonax alnorum	alder flycatcher
Empidonax minimus	least flycatcher
Gallinago gallinago	Wilson's snipe (common snipe)
Gavia immer	common loon
Geothlypis trichas	common yellowthroat
Grus canadensis	sandhill crane
Iridoprocne bicolor	tree swallow
Junco hyemalis	dark-eyed junco
Loxia leucoptera	white-winged crossbill
Parus atricapillus	black-capped chickadee
Pelecanus erythrorhynchos	American white pelican
Perisoreus canadensis	gray jay
Poecile hudsonicus	boreal chickadee
Porzana carolina	sora
Regulus calendula	ruby-crowned kinglet
Seiurus aurocapillus	ovenbird
Strix nebulosa	great gray owl
Tringa flavipes	lesser yellowlegs
Troglodytes troglodytes	winter wren
Vermivora celata	orange-crowned warbler
Vermivora peregrina	Tennessee warbler
Vireo olivaceus	red-eyed vireo
Zonotrichia albicollis	white-throated sparrow
Fish	
Catostomus catostomus	Longnose sucker
Catostomus commersoni	White sucker

Scientific Name	Common Name
Coregonus artedi	Cisco
Coregonus clupeaformis	Lake whitefish
Cottus cognatus	Slimy sculpin
Cottus ricei	Spoonhead sculpin
Couesius plumbeus	Lake chub
Culea inconstans	Brook stickleback
Esox lucius	Northern pike
Etheostoma exile	Iowa darter
Lota lota	Burbot
Margariscus margarita	Pearl dace
Notropis blennius	River shiner
Notropis hudsonius	Spottail shiner
Perca flavescens	Yellow perch
Percopsis omiscomaycus	Trout perch
Pungitius pungitius	Ninespine stickleback
Sander vitreus	Walleye
Thymallus arcticus	Arctic grayling
Flora	
Betula	Birch
Carex	Sedge grasses
Ceratophyllum	Coontail
Elodea	Water weed
Equisetum	Horse tail
Larix	Tamarack
Myriophyllum	Water milfoil
Nuphar	Pond lily
Phragmites	Reeds
Picea	Spruce
Polygonum	Smartweed
Populus	Poplar
Potamogeton	Pondweed
Salix	Willow
Scirpus	Bulrush
Typha	Cattail
Benthic Invertebrates	
Ablabesmyia	Non-biting midge
Agrypnia	Caddisfly
Bezzia	Biting midge
Callibaetis	Mayfly
Ceriodaphnia	Water flea
Chironomus	Non-biting midge
Chrysops	Deerfly
Cladotanytarsus	Non-biting midge
Clinotanypus	Non-biting midge
Corynoneura	Non-biting midge
Cricotopus	Non-biting midge
Cryptochironomus	Non-biting midge
Culicoides	Biting midge
Isotomus	Springtail
Daphnia	Water flea

Scientific Name	Common Name
Dasyhelea	Biting midge
Demicryptochironomus	Non-biting midge
Dicrotendipes	Non-biting midge
Endochironomus	Non-biting midge
Gammarus lacustris	Scud
Gyraulus	Freshwater snail
Heterotrissocladius	Non-biting midge
Helobdella stagnalis	Leech
Hyalella azteca	Scud
Isotomus	Springtail
Labrundinia	Non-biting midge
Micropsectra	Non-biting midge
Microtendipes	Non-biting midge
Nanocladius	Non-biting midge
*Nematoda	Roundworm
*Oligochaeta	Aquatic earthworm
Orthocladius	Non-biting midge
Pagastiella	Non-biting midge
Paracladopelma	Non-biting midge
Paralauterborniella	Non-biting midge
Parakiefferiella	Non-biting midge
Paratanytarsus	Non-biting midge
Pisidium	Freshwater clam
Polypedilum	Non-biting midge
Probezzia	Biting midge
Procladius	Non-biting midge
Pseudochironomus	Non-biting midge
Saetheria	Non-biting midge
Stempellina	Non-biting midge
Stictochironomus	Non-biting midge
Tanytarsus	Non-biting midge
Valvata sincera	Freshwater snail
Ablabesmyia	Non-biting midge
Agrypnia	Caddisfly
Bezzia	Biting midge
Callibaetis	Mayfly
Ceriodaphnia	Water flea
Chironomus	Non-biting midge
Chrysops	Deerfly
Cladotanytarsus	Non-biting midge
Clinotanypus	Non-biting midge
Corynoneura	Non-biting midge
Cricotopus	Non-biting midge
Cryptochironomus	Non-biting midge
Culicoides	Biting midge
Isotomus	Springtail

Scientific Name	Common Name
Daphnia	Water flea
Dasyhelea	Biting midge

– = No common/scientific name available.
* = Taxonomic group

1 REFERENCES

Bouchard, R.W., Jr. 2004. *Guide to Aquatic Invertebrates of the Upper Midwest. University of Minnesota, St. Paul*. 208 pp.

Burt, W.H. 1976. *A Field Guide to the Mammals of America North of Mexico. 3rd Edition*. Houghton Mifflin Co. Boston, MA.

Clifford, H. F. 1991. *Aquatic Invertebrates of Alberta*. University of Alberta Press. Edmonton, AB. 538 pp. ISBN: 0-8864-223-4 (Bound), 0-8864-234-2 (Paperback).

Johnson, D., L. Kershaw, A. MacKinnon and J. Pojar. 1995. *Plants of the Western Boreal Forest and Aspen Parkland*. Lone Pine Publishing. Edmonton, AB.

Merritt, R. W. and K. W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America*. 3rd Edition. Kendall/Hunt Publishing Company. Dubuque, IA. 862 pp. ISBN: 0787232416 / 9780787232412.

Moss, E.H. 1983. *Flora of Alberta. 2nd Edition (Revised by Packer, J.G.)*. University of Toronto Press. Toronto, ON. 687 pp.

National Geographic Society. 1983. *Field Guide to the Birds of North America*. National Geographic Book Service. 464 pp.

Nelson, J.S. and M.J. Paetz. 1992. *The Fishes of Alberta. 2nd Edition*. University of Calgary Press. Calgary, AB.

Russell, A.P. and A.M. Bauer. 1993. The *Amphibians and Reptiles of Alberta*. University of Calgary Press. Calgary, AB. 264 pp.

Smith, H.C. 1993. *Alberta Mammals: An Atlas and Guide*. The Provincial Museum of Alberta. Edmonton, AB. 239 pp. + Maps.

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 Cenovus FCCL Ltd. (Cenovus) Christina Lake Thermal Expansion Project - Phase H and Eastern Expansion (the Project). These procedures were implemented to ensure that the data collected are of known, acceptable and defensible quality and that proper procedure (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 EIA team includes a management team to oversee the entire EIA 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 methods, 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.

SWIs were also used for field sampling programs. SWIs included: 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 data sheets 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. The COC 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. Field Crew Lead retained 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 Field 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 Associates Ltd.'s (Golder's) Health and Safety department as well as to Cenovus.

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 datasets. 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 was completed, 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 components and Cenovus 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 Cenovus were photocopied along with the accompanying transmittal and were stored in the Project master files.
- Documents received from external parties 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 Reviewer 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 was reviewed first by the Component Lead and then by a Senior Reviewer before it was submitted to the EIA Management Team. Once received by the EIA Management Team, each document underwent an extensive review and documentation process including:

- complete document formatto ensure 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 Cenovus representatives;
- review of all comments and edits received from Cenovus representatives with document authors to ensure technical content was not compromised; and all questions and comments were addressed; and
- final review and approval by the Project Manager, Project Director and Cenovus 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.

1 ABBREVIATIONS

%	Percent
CAEAL	Canadian Association for Environmental Analytical Laboratories
COC	Chain-of-Custody
e.g.	For example
EIA	Environmental Impact Assessment
Cenovus	Cenovus Energy Inc.
Golder	Golder Associates 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

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

This section has been prepared to summarize the findings for potential climate change effects and to address regulatory guidance about climate change issues.

2 CLIMATE CHANGE

2.1 ASSESSMENT APPROACH

To evaluate the potential effects of climate change on the Project and the assessment predictions as required by the Terms of Reference (TOR), an understanding of historic climate changes is required 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 1951 to 2000. These data were used to determine recent climatic trends in the Lease 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) have been considered to provide 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 effects 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). Canadian forecast data from these models have been made available by the CICS as part of the Canadian Climate Impacts Scenarios Project.

Table 1 General Circulation Models Considered in the Assessment

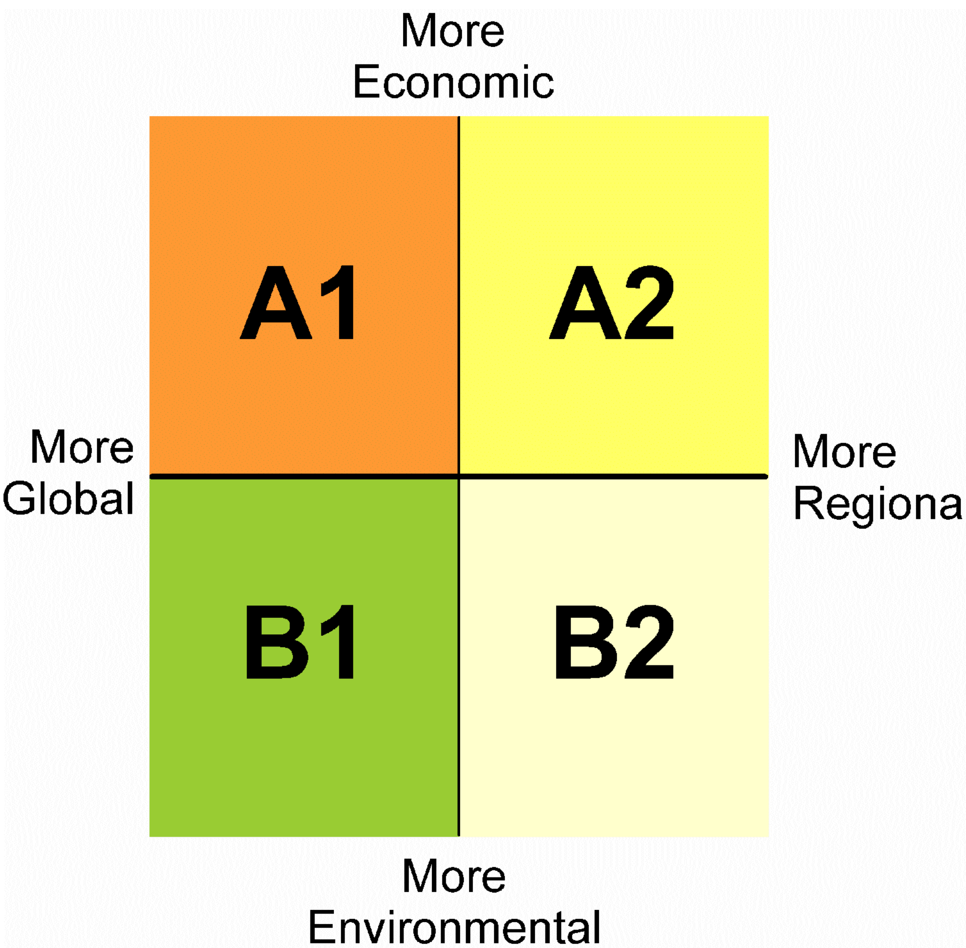
Research Centre/Model Name	Abbreviation	Country	Model Resolution[a] [km²]
Centre for Climate System Research/National Institute for Environmental Studies	CCSR/NIES	Japan	168,000
Canadian Global Coupled Model (Version 2)	CGCM2	Canada	74,000
Commonwealth Scientific and Industrial Research Organization 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 Canadian Institute for Climate Studies internet site (CICS 2005).

2.1.2 Forecast Scenarios

Given the wide range of inputs available to GCMs, the IPCC has established a series of global greenhouse gas (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. Illustrative summaries of the four emission scenarios, which are described more fully in the *IPCC Special Report on Emissions Scenarios* (IPCC 2000), are provided in Figure 1.



PROJECT

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE EMISSION SCENARIOS

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B001
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013		
CHECK	DC	22/02/2013		
REVIEW	SS	22/02/2013		

FIGURE: 1

L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig1_10134600448000B001PanelClimChng.dwg Feb 25, 2013 - 8:42am

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.
- Balanced (B): a socio-economic condition that relied on both fossil fuels and non-fossil-fuels.

While the IPCC supports all of these scenarios, forecast data are 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. There are six models that were used to investigate the various forecast scenarios. Not all models investigated every forecast scenario so within the set of six models that were used to investigate individual emissions scenarios there are a total of 26 available climate forecast combinations.

Table 2 Summary of Available Climate Forecasts

Climate Model	Forecast Period	Special Report on Emissions Scenarios[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 Special Report on Emissions Scenarios (IPCC 2000) 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 Canadian Institute for Climate Studies internet site (CICS 2005).

n/d = No data.

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).

The IPCC recommends that 1961 to 1990 be adopted as the climatological baseline period in assessments (CICS 2005). This period has been selected because 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 effects; and
- be comparable with baseline climatology used in other effects 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 Lease Area were obtained from the Cold Lake Airport meteorological station which is operated by the Meteorological Service of Canada (Environment Canada 2007). 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). Data for 1981 to 2010 is not yet available from Environment Canada. A summary of the climate normals observed at Cold Lake is provided in Table 3. 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

Source: Environment Canada (2007)

The observed changes in climate conditions relative to the 1961 to 1990 climate normals are listed in Table 4. 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.

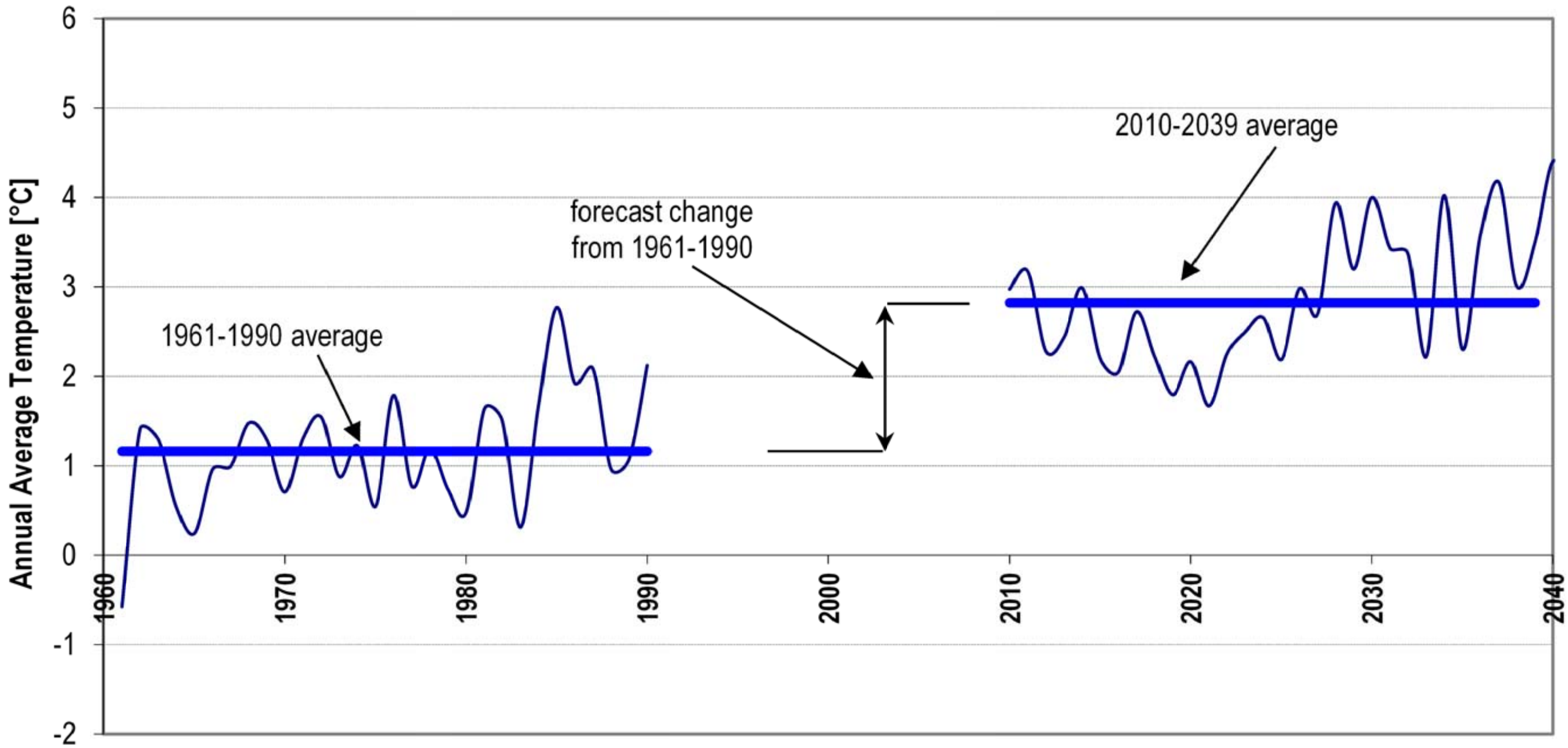
The forecast changes in temperature and precipitation between the baseline and future conditions (i.e., 2010 to 2039), presented in Tables 5 through 10, were determined for each of the models/scenarios available on the CICS internet site (CICS 2005) for the corresponding model grid cell that covered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

The annual climate change forecasts relative to the baseline period are illustrated in Figure 3, while the summer and winter change forecasts are illustrated in Figure 4. Both figures are based on the data in Tables 5 to 10.

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 is provided in Table 11. 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%.

L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig2_10134600448000B002ClimChngBase1961-90.dwg Feb 22, 2013 - 3:26pm

Image:Cenovus_2CLR.jpg



PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

DETERMINING CLIMATE CHANGE RELATIVE TO BASELINE (1961 TO 1990)

Golder Associates

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B002
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013		
CHECK	DC	22/02/2013	**FIGURE: 2**	
REVIEW	SS	22/02/2013		

Table 5 CCSR/NI ES Climate Forecasts Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario[a]	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

[a] Special Report on Emissions Scenarios (IPCC 2000).

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

Table 6 CGCM2 Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario[a]	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

[a] Special Report on Emissions Scenarios (IPCC 2000).

Table 7 CSIRO Mk2b Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario[a]	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

[a] SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 8 ECHAM4/OPYC3 Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

Climate Model	SRES Scenario[a]	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

[a] SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 9 GFDL R30 Climate Forecasts for 2010 to 2039 Relative to Baseline (1961 to 1990)

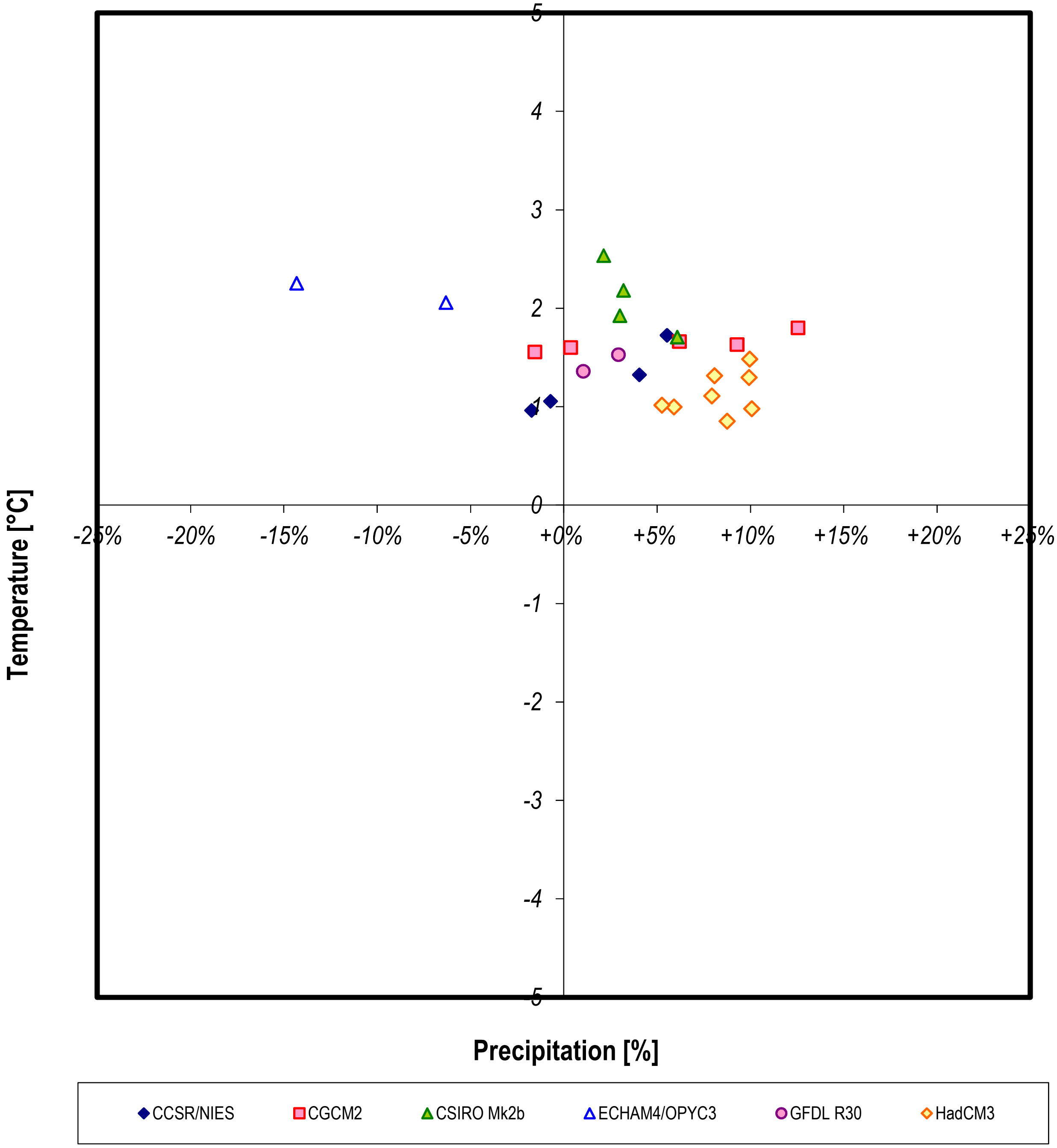
Climate Model	SRES Scenario[a]	Season	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
GFDL R30	A2(1)	annual	+1.5	+2.9
		summer	+1.2	+4.5
		winter	+1.9	+6.0
GFDL R30	B2(1)	annual	+1.4	+1.1
		summer	+2.2	-12.4
		winter	+0.9	+3.4

[a] 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[(a)]	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

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



PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

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

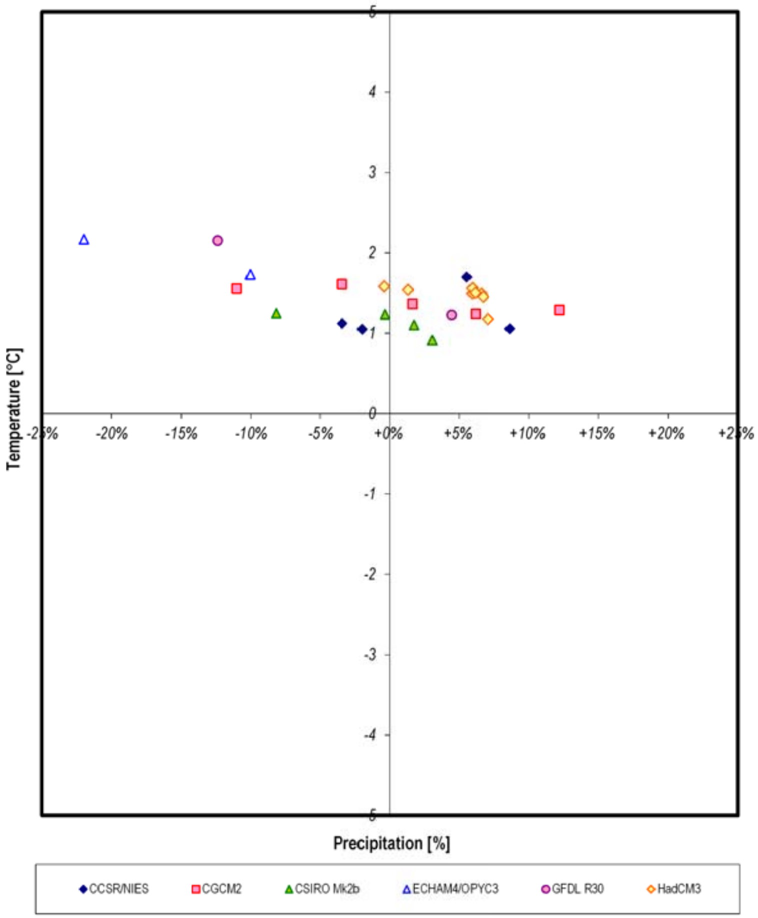
Golder Associates

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B003
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013		
CHECK	DC	22/02/2013	**FIGURE: 3**	
REVIEW	SS	22/02/2013		

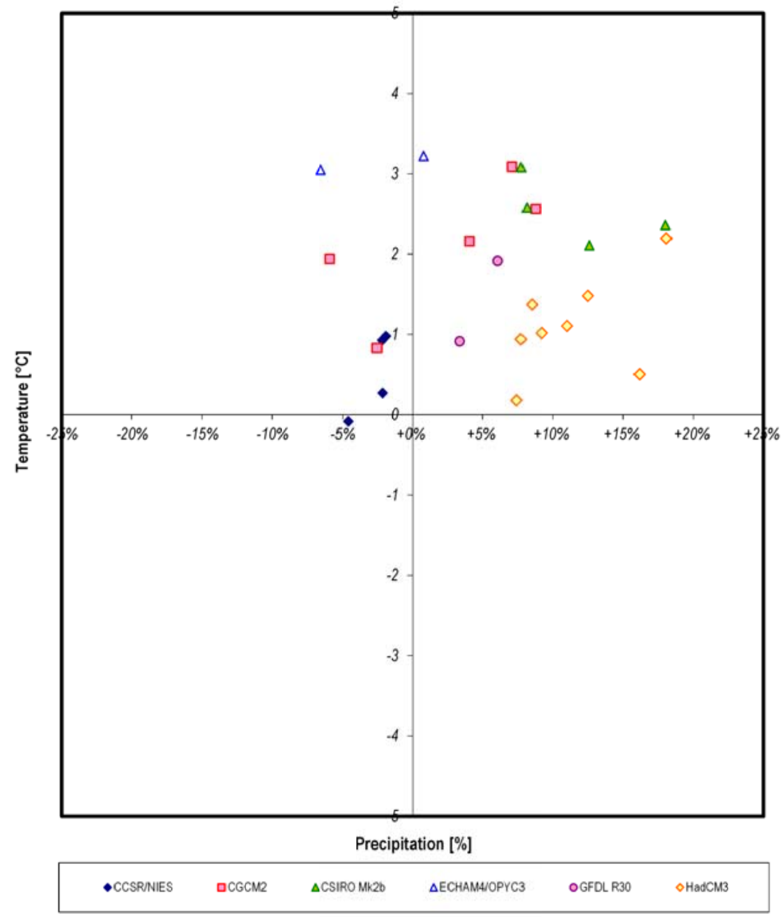
L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig3_10134600448000B003ClimateChng1961-90.dwg Feb 22, 2013 - 3:23pm

L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig4_10134600448000B004SumWinChngBase.dwg Feb 22, 2013 - 3:23pm

Image:Cenovus_2CLR.jpg



Summer



Winter

PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

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

Golder Associates

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B004
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013		
CHECK	DC	22/02/2013	FIGURE: 4	
REVIEW	SS	22/02/2013		

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, 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)

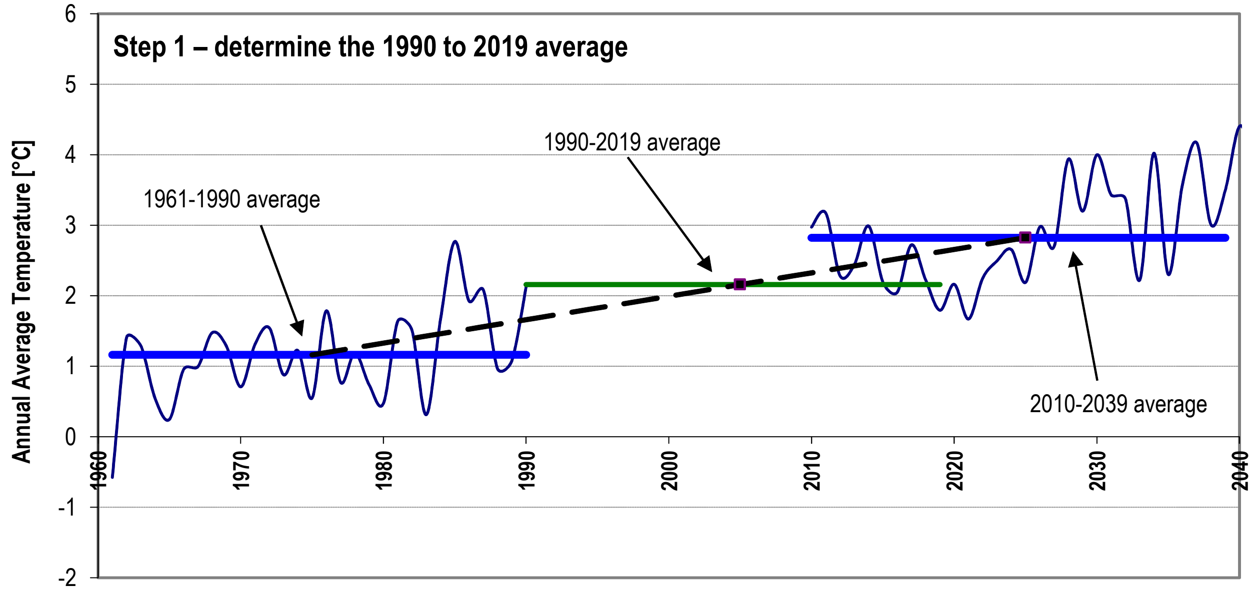
Ranking Method	Rank	Model and SRES Scenario[(a)]	Change from Baseline (1961 to 1990)	
			Temperature [°C]	Precipitation [%]
annual temperature	3rd highest	CSIRO Mk2–B1(1)	+2.2	+3.2
	12th highest	CCSR/NIES–A1(1)	+1.6	+0.0
	23rd highest	HadCM3–A2(3)	+1.0	+5.9
summer temperature	3rd highest	ECHAM4/OPYC3-B2(1)	+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

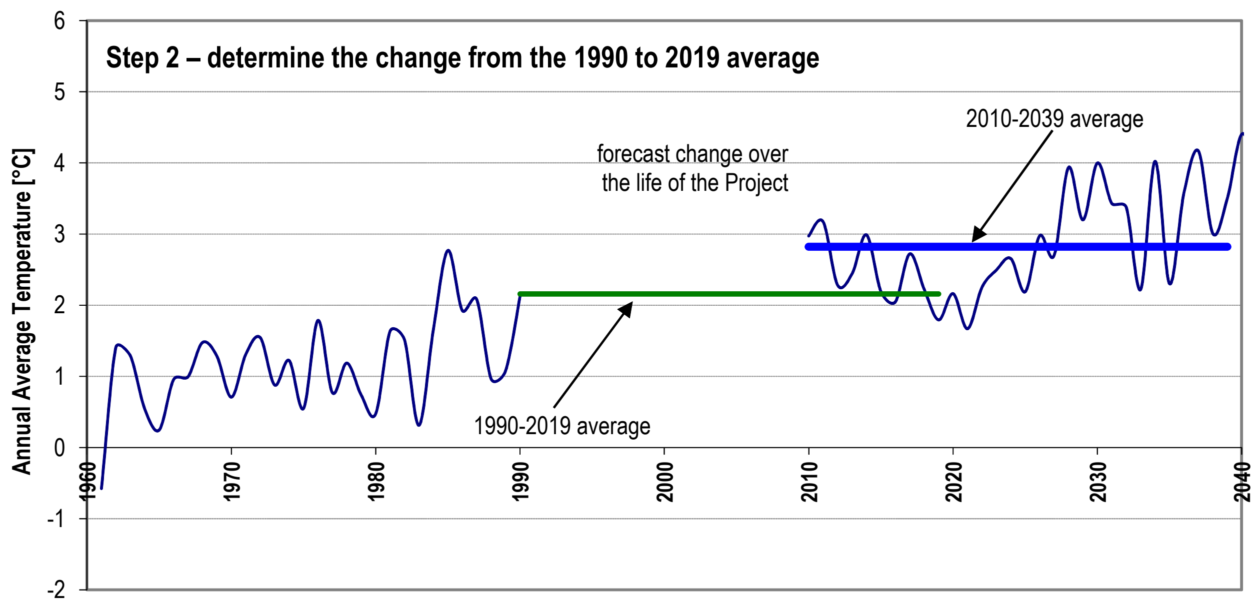
(a) SRES = Special Report on Emissions Scenarios (IPCC 2000).

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 important for comparison to historic observations to provide a measure of the performance of the forecasts, the baseline models do not predict 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 approach 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.

Future changes in temperature and precipitation have been determined for each of the 26 model and scenarios combinations. 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 is provided in Tables 13 to 18.





PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

DETERMINING CLIMATE CHANGE OVER THE PROJECT LIFE

Golder Associates

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B005
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013		
CHECK	DC	22/02/2013	**FIGURE: 5**	
REVIEW	SS	22/02/2013		

L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig5_10134600448000B005DeterClimChng.dwg   Feb 22, 2013 - 3:23pm

Table 13 CCSR/NIES Climate Forecasts Over the Project Life

Climate Model	SRES Scenario[(a)]	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

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

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

Table 14 CGCM2 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario[(a)]	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

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

Table 15 CSIRO Mk2b Climate Forecasts Over the Project Life

Climate Model	SRES Scenario[a]	Season	Change Over Project Life Temperature [°C]	Change Over Project Life 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

[a] SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 16 ECHAM4/OPYC3 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario[a]	Season	Change Over Project Life Temperature [°C]	Change Over Project Life 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

[a] SRES = Special Report on Emissions Scenarios (IPCC 2000).

Table 17 GFDL R30 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario[a]	Season	Change Over Project Life Temperature [°C]	Change Over Project Life 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

[a] SRES = Special Report on Emissions Scenarios (IPCC 2000).

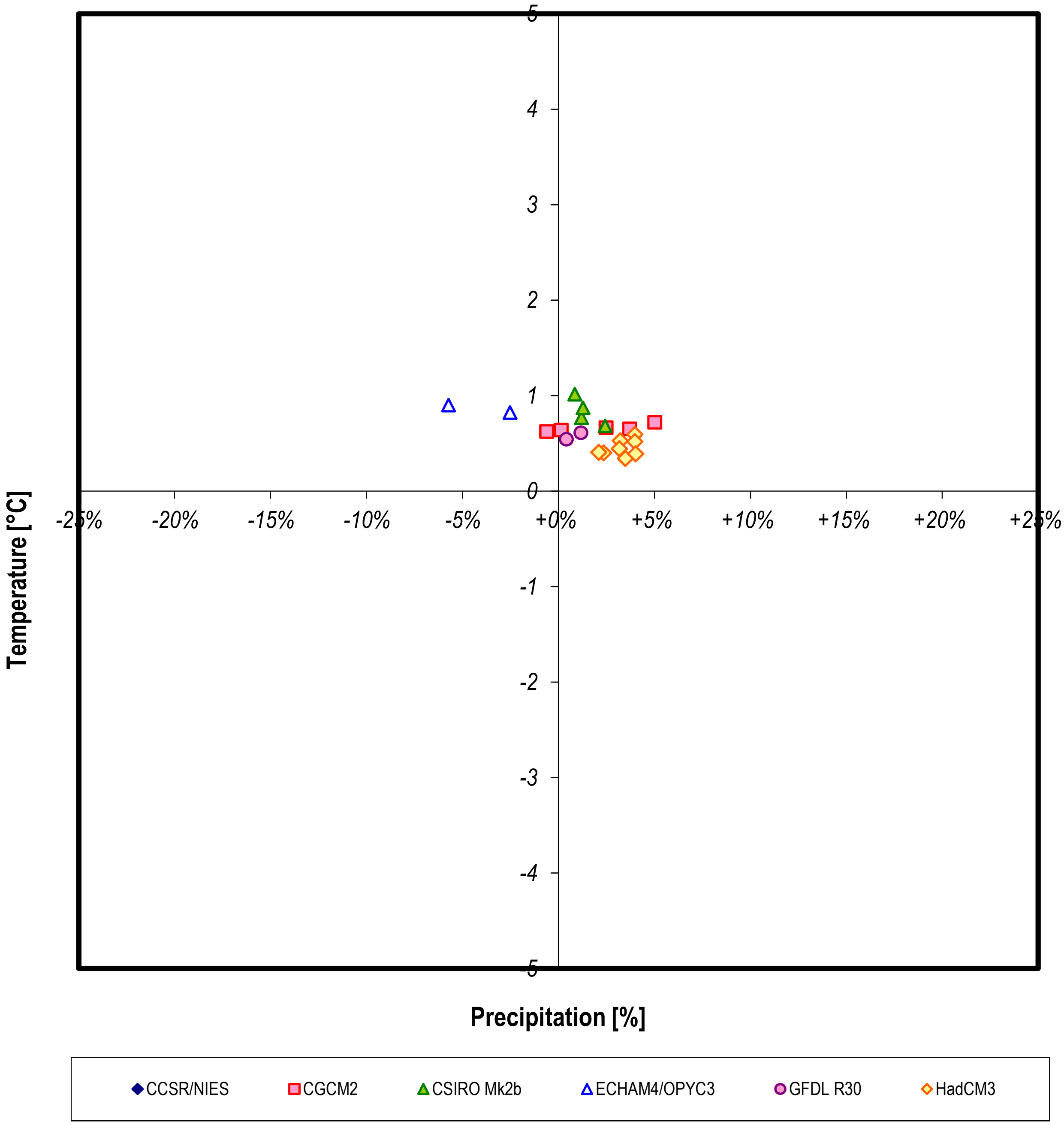
Table 18 HadCM3 Climate Forecasts Over the Project Life

Climate Model	SRES Scenario[a]	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

[a] SRES = Special Report on Emissions Scenarios (IPCC 2000).

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

A summary of the forecast changes in temperature and precipitation over the life of the Project is provided in Table 19. 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

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

FORECAST ANNUAL CLIMATE CHANGE OVER THE PROJECT LIFE

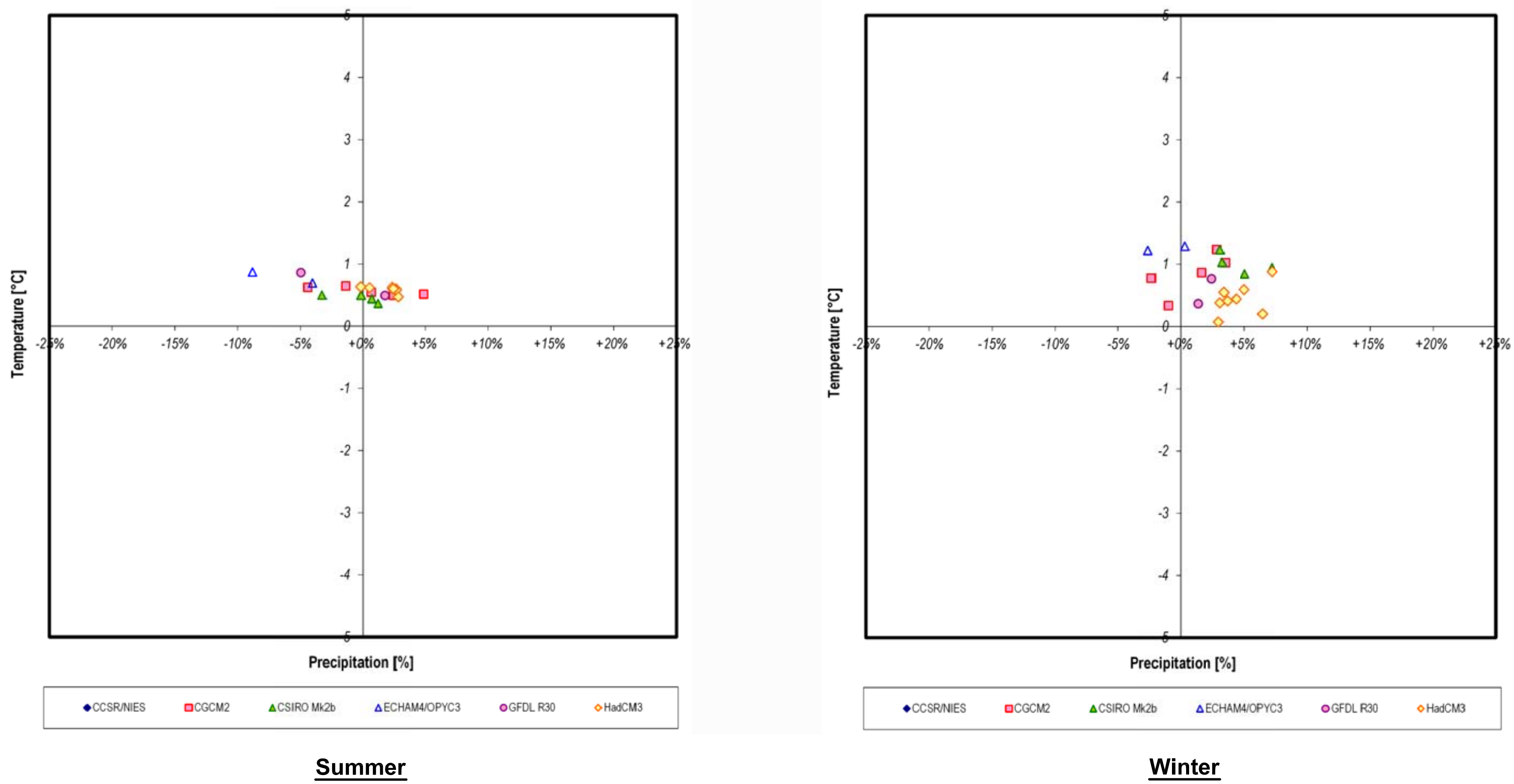
Golder Associates

PROJECT	10.1346.0044.8000	
DESIGN	RM	07/01/2013
CADD	BSW	08/01/2013
CHECK	DC	22/02/2013
REVIEW	SS	22/02/2013

FILE No. 10134600448000B006
SCALE AS SHOWN REV. 0

FIGURE: 6

L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig6_10134600448000B006ClimateChngLife.dwg Feb 22, 2013 - 3:22pm



PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

FORECAST SUMMER AND WINTER CLIMATE CHANGE OVER THE PROJECT LIFE

Golder Associates

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B007
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013	FIGURE: 7	
CHECK	DC	22/02/2013		
REVIEW	SS	22/02/2013		

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 Section 2.3.1, 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[a]	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
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

[a] Special Report on Emissions Scenarios (IPCC 2000).
n/a = Not available.

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 are carried forward into the assessment. These nine combinations of models and scenarios are consistent with the Burn (2003) recommendations for representing the upper bounds for changes in temperature and upper and lower bounds for changes in precipitation. The results of these combinations and the upper bounds are shown in Tables 21 to 29. For reference, the tables include the change from the baseline information for each model forecast.

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 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 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 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 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 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 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 23rd highest ranking for titled climate parameter.

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 23rd highest ranking for titled climate parameter.

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 23rd highest ranking for titled climate parameter.

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

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

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

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

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

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

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

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

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

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 Environmental Impact Assessment (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

Climate change should not directly affect the predictions of Potential Acid Input (PAI) presented in the EIA; however, increased rainfall could lead to higher wet deposition and higher predictions of PAI. Warming temperatures that could cause a shift from snowfall to rainfall could be an incremental contributor 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

Because 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, the 2002 to 2006 meteorological data set used to model PAI in the Project region can be compared with the observed climate normals to confirm if the current predictions indicate how changing climate may affect the PAI.

The 2002 to 2006 meteorological data that were used to model PAI to the 1961 to 1990 Cold Lake climate normals are compared in Table 32. The annual total precipitation during the 2002 to 2006 period ranged from 38% below normal to 33% above normal. During the summer, total precipitation ranged from 49% below normal to 39% above normal.

Table 32 Comparison of 2002 to 2006 Precipitation Observations to Climate Normals

Season	1961 to 1990 Normals [mm]	Observed Precipitation over 2002 to 2006 Period [mm]	Range of Differences from Normals [%]
annual	432.4	269.3 to 575.1	-38 to +33
spring	78.7	73.0 to 198.9	-7 to +153
summer	221.9	114.1 to 309.5	-49 to +39
fall	76.8	52.0 to 147.2	-32 to +92
winter	54.6	12.8 to 76.6	-77 to +40

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. Since the predicted change in summer precipitation is within the range of the 2002 to 2006 meteorological data, when compared to the 1961 to 1990 normals, the meteorological data used in the modelling provides a conservative estimate of the current deposition rates and expected future rates. The effects of climate change are, therefore, not expected to affect the conclusions of the air quality assessment with respect to acid deposition.

3.3 ATMOSPHERIC DISPERSION

The range of forecast wind speed changes from the baseline and over the Project life is summarized in Table 33. 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.

The forecast change in wind speed for the ranked scenarios over the Project life is shown in Table 34. 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 required to complete dispersion modelling for the Project region. However, it is possible to compare the 2002 to 2006 meteorological dataset 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[a]	Wind Speed Change [%] Change Between the Averages of Baseline and 2010 to 2039	Wind Speed Change [%] 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

[a] Special Report on Emissions Scenarios (IPCC 2000).
n/a = Not available.

How the average wind speeds over the 2002 to 2006 period are compared to the long-term normals for the region is shown in Table 35. During the 2002 to 2006 period, the annual wind speeds were 4% below the climate normals. The largest forecast change in wind speed from baseline is -7.0%.

Table 35 Comparison of 2002 to 2006 Average Wind Speeds to Climate Normals

Season	Average Wind Speed [km/hr] 1961 to 1990 Normals	Average Wind Speed [km/hr] 2002 to 2006 Observation	Difference from Normals [%]
annual	12.1	11.6	-4
spring	13.1	13.4	+2
summer	12.3	11.8	-3
fall	12.2	11.2	-9
winter	10.6	9.5	-10

The frequency of occurrence of different wind speed categories for the 1961 to 1990 normals and the 2002 to 2006 period is shown in Table 36. Overall, the 2002 to 2006 period had a similar number of hours with wind speeds between 1 km/hr and 5 km/hr, and between 16 km/hr and 20 km/hr. There were slightly fewer hours with calm conditions and with wind speeds greater than 20 km/hr compared to the climate normals. There were also slightly more hours with wind speeds between 6 km/hr and 15 km/hr.

Table 36 Comparison of Wind Speed Categories

Wind Speed Category	Frequency of Occurrence [%]		Difference from Normals [%]
	1961 to 1990 Normals	2002 to 2006 Observation	
calm	12	10	-2
1 to 5 km/hr	9	9	0
6 to 10 km/hr	26	30	+4
11 to 15 km/hr	23	24	+1
16 to 20 km/hr	15	15	0
>20 km/hr	16	12	-4

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, the 2002 to 2006 data used to model concentrations in the region had annual average wind speeds slightly below historic observations and had a similar number of hours with lower wind speeds. Therefore, it is expected that the 2002 to 2006 wind speed data used in the assessment of climate change and air quality result in ground-level concentrations that are similar to those obtained if historic normals were used. The effects of climate change are, therefore, 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. 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 (AENV 2011) suggests that photochemical reactions are relatively weak in the region. This result 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.

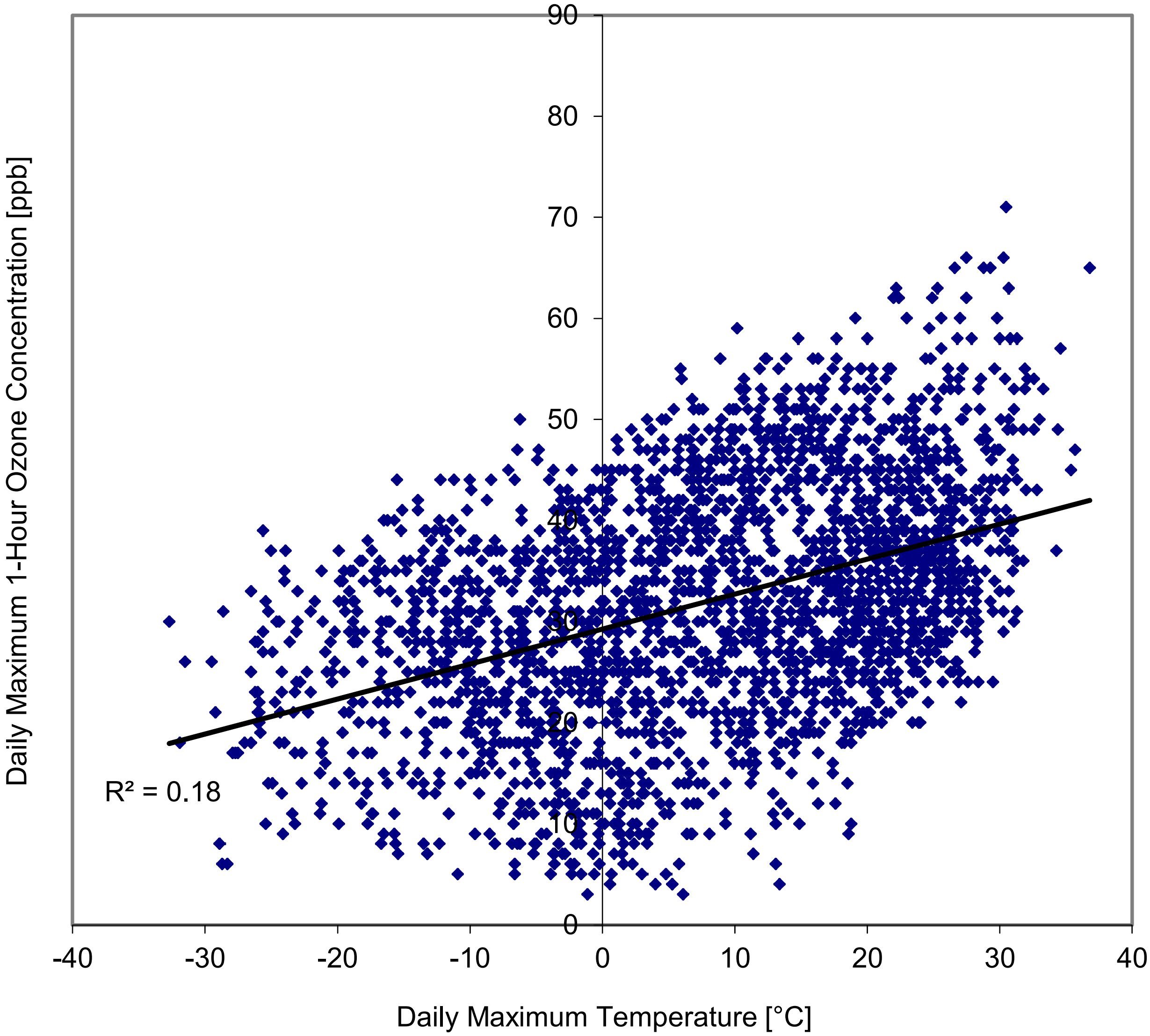
Summer temperature is one of the climate parameters likely to affect ground-level ozone concentrations. The forecasts from the ECHAM4/OPYC3 model for scenario B2(1) yielded the upper summer temperatures over the life of the Project. The climate trends forecast for that model and scenario combination are summarized in Table 37 (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). A comparison of daily maximum temperatures and the corresponding 1-hour maximum ozone concentration is presented in Figure 8. These data were 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 = 0.18, assuming a linear trend). On days when temperatures are greater than 30ºC, ozone concentrations range from approximately 24 to 71 ppb. High ozone concentrations also occur 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, it is predicted that these changes may not correspond to increased peak ozone concentrations.



L:\2010\1346\10-1346-0044\8000\Appendix_2\Report_B\Fig8_10134600448000B008TempVsOzone.dwg Feb 22, 2013 - 3:22pm

PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

COMPARISON OF DAILY MAXIMUM TEMPERATURES AND DAILY MAXIMUM 1-HOUR OZONE CONCENTRATIONS

Golder Associates

PROJECT	10.1346.0044.8000		FILE No.	10134600448000B008
DESIGN	RM	07/01/2013	SCALE AS SHOWN	REV. 0
CADD	BSW	08/01/2013		
CHECK	DC	22/02/2013	**FIGURE: 8**	
REVIEW	SS	22/02/2013		

3.5 SUMMARY

In conclusion, the air quality predictions in the assessment are considered representative of conditions over the life of the Project because the 2002 to 2006 meteorological data (temperature and wind speed) cover the range of climate forecast values. Since the predicted change in summer precipitation is within the range of the 2002 to 2006 meteorological data, when compared to the 1961 to 1990 normals, the meteorological data used in the modelling provides a conservative estimate of the current deposition rates and expected future rates. 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.

4 EFFECT OF CLIMATE CHANGE ON HYDROLOGY PREDICTIONS

4.1 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 affect key climatic factors, most notably precipitation and temperature, which affect hydrology. The hydrologic variables that may be affected by climate change due to changes in temperature and precipitation are summarized in Table 38.

Table 38 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 decreased channel-forming flows and hence change in stream geomorphology

4.2 REVIEW OF KEY CLIMATE FACTORS WITH AN INFLUENCE ON HYDROLOGY

The potential effects 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 are evaluated in Section 2 of this Appendix.

The analysis of climate normals for Cold Lake for the periods 1951 to 1980, 1961 to 1990 and 1971 to 2000 is presented in Section 2.2 of this appendix. The results of this analysis are 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 mm 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. 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 summarized in Table 39. This table summarizes the information presented in Tables 21 through 29 in Section 2.4.

Table 39 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 39 are summarized as follows:

- The 3rd highest GCM forecasts temperature 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°C to 1.6°C.

In addition to long-term seasonal and annual changes to temperature and precipitation, there is a possibility of effects from climate change on extreme precipitation events, which could in turn affect 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.

4.3 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 effects 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 1.5% of the most affected sub-watershed (Christina Lake at its outlet with the drainage area of 1,281 km^2). 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 less than 4% relative to pre-development conditions. Existing and approved developments also contribute to a predicted increase in runoff of about 17%, for a total change of 21% relative to pre-development conditions. Potential effects within some watersheds are potentially higher, with predicted runoff increases of up to 27% due to existing and approved projects and the Project. Upon reclamation, the effects of surface disturbances on hydrology will be significantly reduced.

The GCMs indicated a general agreement in predicting increased temperature within the Lease Area, and therefore increased evaporation and evapotranspiration is expected. There is less agreement between models on changes to precipitation: the 3rd highest GCMs predict 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 effect 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 Cenovus 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.

4.4 SUMMARY

Predicting the magnitude of the potential effects of climate change on hydrology within the LSA and RSA is associated with considerable uncertainty. 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 effects 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 effect of the Project on local hydrology is predicted to be small. The predicted changes resulting from climate change are not expected to change the predictions of the EIA.

5 EFFECT OF CLIMATE CHANGE ON SURFACE WATER QUALITY PREDICTIONS

5.1 INTRODUCTION

The Project's effects on surface 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 40). 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 5.2. The interrelation of climate change and potential effects of the Project on water quality are described in Section 5.3.

Table 40 Primary Links Between Climate Change and Surface Water Quality

Water Quality Change	Change in Temperature (Increase)	Change in Precipitation	
		Increase	Decrease
indirect changes to water quality	• 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

5.2 LITERATURE REVIEW

Most of the existing climate change literature has focused on effects of climate change on meteorological parameters, such as air temperature and precipitation, rather than 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).

The global mean surface air temperature has risen about 0.7°C ± 0.2°C during the 20th century, and the last decade was the warmest in the Northern Hemisphere during the instrumental record (IPCC 2007a,b). Air temperature is anticipated to increase even more in the future; for example, global circulation models driven by scenarios of a doubling of carbon dioxide (CO_2) and increases in other atmospheric greenhouse gases predict an increase from 1.5°C to 5°C in average air temperature by the year 2100. There is clear evidence of a strong relationship between climatic conditions (e.g., air temperature and wind patterns) and lake thermal structure, e.g., onset of stratification, thermocline depth, mean epilimnetic temperature and duration of ice cover (Magnuson et al. 1997; Schindler 1997). Shimoda et al. (2011) reviewed the thermal structure of 12 northern temperate deep lakes and reported increases in temperature ranging from 0.01 to 0.1°C per year.

Changes in streamflow due to climate warming have the potential to alter streamflows and sediment loadings to local waterbodies. Milly et al. (2005) used an ensemble of 12 climate models in simulating observed regional patterns of 20th-century multidecadal changes in streamflow. These models projected 10% to 40% increases in runoff in eastern equatorial Africa, the La Plata basin of South America, and high latitude North America and Eurasia, and 10% to 30% decreases in runoff in southern Africa, southern Europe, the Middle East and mid-latitude western North America by the year 2050.

Anthropogenic (human-induced) effects, such as changes in land and water use management related to climate change, may have similar or greater effects 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.

Most of the literature that describes potential effects of climate change on water quality focuses on water temperature, dissolved oxygen and nutrients. 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; Shimoda et al. 2011). 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 through atmospheric mixing and sunlight penetration into water column.

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 concentration of oxygen in the water column (Thomann and Mueller 1987). Consistent with this result, a study by Flanagan et al. (2003) compiled the algal biomass data from 57 sources ranging in latitudes from 41°N to 79°N and reported that higher algal biomass was recorded in lower latitude systems.

In addition, Shimoda et al. (2011) demonstrated through both empirical evidence and model predictions that the advancement of the spring phytoplankton bloom timing is an established pattern in north temperate lakes regardless of their trophic status. Whether responding to the earlier stratification onset or to a relaxation of turbulent vertical mixing independently of the upper water-column depth, the spring phytoplankton bloom has advanced by an average of 1 to 2 weeks to date. As a consequence, the warmer spring weather may result in lower chlorophyll *a* maximum due to an earlier appearance and faster zooplankton grazing rates.

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) and Shimoda et al. (2011) reported increased thermal stability and 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 and chemical constituents from hypolimnion to epilimnion. As a result, 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; Shimoda et al. 2011). 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. Schindler (2001) indicated that the rise of water temperature may increase bioaccumulation and biomagnification of organic and inorganic chemicals and thus have detrimental ramifications on entire aquatic food webs. However, these hypotheses are yet to be tested.

Based on these studies, it appears that the main pathway for effects on water quality may be through changes in water temperature and surface flow. Increase water temperature may increase solubility and influence primary productivity. 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.

5.3 ANALYSIS

Although an effect of climate change 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 influence the predicted effects of the Project on water quality.

The GCMs indicated a general agreement in predicting 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. This effect, however, is likely to be very small and independent of the Project and increases in temperature will not change any of the Project's effects on the surface waters.

The models do not show a strong agreement 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, including sediments carried by runoff, will be contained in the industrial runoff control system. This mitigation will include active site drainage to stormwater ponds at the central plant site and containment berms at SAGD well pad sites. The collected runoff will be tested and discharged back to the environment, if *Environmental Protection and Enhancement Act* discharge limits are met. With this level of runoff water management, it is not expected that increased runoff will have a significant effect on surface water quality. The increased site runoff could also be limited by the increased evaporation due to the predicted temperature increase (Section 5.3). Planned management practices are not expected to change as a result of changes in the climate. The conclusions of the water quality assessment are not expected to change as a result of climate change.

5.4 SUMMARY

Based on Cenovus'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.

6 EFFECT OF CLIMATE CHANGE ON FISH AND FISH HABITAT PREDICTIONS

6.1 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 41.

Table 41 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 of 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

6.2 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 6.3. The assessment was also based on the outcome of the analyses conducted by the hydrology (Section 4.3) and water quality (Section 5.3) 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 effects of the Project on thermal regime in any watercourse or waterbody and, therefore, no predicted cumulative effects resulting from climate change.

6.3 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). Many of these physical changes are interrelated but for practical purposes can be placed into the following 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 Lease Area, potential linkages of climate change to physical changes to aquatic systems within each of these five categories include the following:

- 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.
- 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.
- 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.
- Reduced system stability:
  - more frequent flooding events;

  - more frequent drought events;
  - increased deposition of organic or inorganic sediments into streams; and
  - fluctuating water levels.
- 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.

6.4 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.

The linkage analysis for effects on fish habitat was considered to be valid through the pathways of changes in winter low flows, direct changes to habitat and increased sediment deposition from the construction of watercourse crossings, and associated changes to benthic invertebrate communities. For changes to stream flows, the direction of the effect on fish habitat was neutral for Sunday and Monday creeks. For the unnamed tributaries on the east side of Christina Lake, the effect was considered to be negative and negligible in magnitude. For watercourse crossings, the direction of the effect on fish habitat was considered to be negative and negligible in magnitude. For benthic invertebrate communities, the effect was considered to be negative in direction and negligible in magnitude. As a result, there was a negligible environmental consequence of the residual effects to fish habitat resulting from the Project.

The linkage analysis for effects on fish abundance was considered to be valid through the pathways of changes in fish abundance due to surface water withdrawals from water intakes and changes to fishing pressure. For both pathways, the direction of the effect was considered to be negative and negligible in magnitude. As a result, there was a negligible environmental consequence of the residual effects to fish abundance resulting from the Project.

The Fish and Fish Habitat assessment for the Project for changes in fish health, and fish and fish habitat diversity predicted no residual effects. Therefore, there was no environmental consequence of the Project on fish health, and fish and fish habitat diversity.

As the potential effects were considered to result in no or negligible residual effects, 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 4), 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 5). 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.

6.5 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.

7 EFFECT OF CLIMATE CHANGE ON TERRESTRIAL RESOURCES PREDICTIONS

7.1 INTRODUCTION

The potential effect of climate change on terrestrial resources considers the degree at which these change may have on vegetation, soils and wildlife. The greatest shift in climate attributes is generally considered to be precipitation and temperature; the potential effects to terrestrial resources are summarized in Table 42.

7.2 APPROACH

Historic changes in temperature and precipitation, as well as future predicted changes of these parameters, were evaluated for the Project. The possible changes to temperature and precipitation were considered in the evaluation of effects to soils and vegetation for the successful reclamation of the 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 the Project will affect the predicted results. 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.

7.3 ANALYSIS

7.3.1 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 was chosen to represent the cooler extent of temperatures. Temperature data from Athabasca to Yellowknife were analyzed 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 are taken from the Canadian Climate Normals 1971 to 2000 (Environment Canada 2012). When this document was written, Environment Canada had not released data beyond the year 2000.

Table 42 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. 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.
Vegetation	• Increases or decreases in precipitation would result in a shift in species composition and diversity depending on terrain and ecosite characteristics. In wetter locations, decreased precipitation could result in a shift to more upland species whereas an increase would mean a shift to more inundation-tolerant species. For dryer locations, a shift towards more drought-tolerant species with a decrease in precipitation, and a shift away from these species with an increase in precipitation.	• Warm and dry summer conditions would potentially increase water demands, reduce leaf area, and reduced biomass production in dryer locations. In wetter locations there could be an increase in biomass production, but a change in species composition. • With increased temperatures, the moisture regime becomes drier which could decrease fire return intervals; this in turn could alter forest biodiversity. • Warm summer temperatures could lengthen the growing season by accelerating snowmelt. • Changes in the climate could alter species interactions by affecting inter- and intra- specific relationships (i.e., competition) within natural communities resulting in a change to biodiversity and species composition. • Species distribution and composition are expected to change with the anticipated change in climate, with a migration of more southern species into the region.
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 1 kg 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.

Average annual temperatures in the boreal forest range from 2.1°C (Athabasca) to -4.6°C (Yellowknife). 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°C 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 area 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°C and –30.9°C, respectively. The minimum monthly temperature in Cold Lake is –21.7°C, with future climate trends predicting between a +1.0°C 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°C and 21.1°C, respectively. 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°C 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 Northwest Territories, 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.

Climatic variables applicable to vegetation growth and the predicted future normals to 2039 are modelled in Tables 21 to 29. 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°C and 16.6°C is predicted for the Cold Lake region. Average winter temperatures are expected to range between –14.5°C and –13.2°C. Annual rainfall is predicted to vary from 416.5 to 444.3 mm per year.

The climate ranges for boreal tree species found in the RSA are listed in Table 43. 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 the ranges of tolerances (Section 2.4) for these species.

Table 43 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).

7.3.2 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). 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 affecting 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 (Brady and Weil 2000). It is primarily accumulated through plants which "fix" the carbon from carbon dioxide; 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).

7.3.3 Vegetation Responses to Climate Change

Research indicates that the southern boundary of the central Canadian boreal forest is limited by moisture regime and fire frequency, while the northern boundary is limited by temperature (Brooks et al. 1998). Because temperature and precipitation are two of the dominant factors that limit the central Canadian boreal forest boundaries, they are predicted to play a similar role in dictating boreal forest boundaries in response to climate change in the boreal forest.

Increased temperature can affect physiological processes of vegetation and ultimately alter ecosystem level dynamics (Schlesinger 1997). Prolonged changes of only a few degrees Celsius can cause drastic changes to the water use efficiency, photosynthesis, respiration and nutrient uptake of established vegetation (Schlesinger 1997). Warm and dry summer conditions increase respiration rates, reduce photosynthesis, reduce leaf area, reduce stored energy reserves and ultimately increase forest mortality to existing vegetation (Allen et al. 2010; Nakawatase and Peterson 2006). In areas that become drier, fire return intervals are expected to become shorter and intensities are expected to increase (Golder

2005; Nakawatase and Peterson 2006). Warm summer temperatures lengthen the growing season by accelerating snowmelt. Since the early 1960s the average annual growing season in boreal forest has lengthened 11 days, and is the result of an increase in mean annual air temperature (Theurillat and Guisan 2001; IPCC 2007a,b). While a longer growing season may increase tree growth initially, the potential lack of precipitation could offset any benefits and increase mortality (Girardin 2008).

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 maximum and minimum precipitation and temperature are generally more important than the annual amounts (Brooks et al. 1998). Bell and Threshow (2002) also indicates that changes to the climate could lead to changes in the development pattern of species, thus affecting inter- and intra-specific relationships (i.e., competition) within natural communities, which can alter species composition and biodiversity.

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 of southern communities northward (McKenney et al. 2007). 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 (McKenney et al. 2007; Scheller and Mladenoff 2005; Walker et al. 2002). Our analysis indicates that the forecasted climate normals for the Cold Lake region are within the climatic ranges of tolerance for boreal tree species (Table 43).

Loehle (2003) states that the rate at which a forest can be invaded by new species, even by a much superior competitor, is limited by the rate at which openings become available (i.e., increased disturbance). Climate change may not cause direct species mortality but could alter competitive interaction among and between species. This could cause fragmentation of vegetation communities leaving an ecosystem vulnerable to invasion from non-native species (i.e., weeds). Intact forests are more resistant to invasion and their response to moderate climate change should be slow with a prolonged transition, although the rate of this transition is not known for boreal forest. Depending on the severity of climate change it could take forests hundreds of years or longer for the population to come to a new equilibrium.

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). Reclaimed ecosystems may be less resistant to invasion than established ecosystems since it does represent a disturbance (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 individualistic, and even the same species performed differently under different climate conditions or when planted with different species (i.e., intra- vs. inter-specific competition). Because forest species in different environments can respond differently to climactic variability, management of forest ecosystems will need to consider growth response at a more local to regional scale rather than relying on global and even continental predictions (Nakawatase and Peterson 2006).

7.3.4 Wildlife Responses to Climate Change

Climate change may affect 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).

The effects of climate change on wildlife 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 limitation 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 effect 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; Li et al. 2000; Natural Resources Canada 2013; Weber and Flannigan 1997). 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 affects 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 2013b). 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 change may cause declines in fish and small-mammal habitats and populations (Environment Canada 2013b).

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).

7.4 SUMMARY

Climate change may have effects on 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. The predicted responses of vegetation 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, 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 Lease Area, will be affected primarily through surface disturbances associated with construction of the Project. Changes to the Lease 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 Lease 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.

8 REFERENCES

AENV. 2011. *Alberta Ambient Air Quality Objectives and Guidelines. Environmental Protection and Enhancement Act*. April 2011.

Allen, C.D., K. A.K. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, T. Kitzberger, A. Rigling, D.D. Breshears, E.H. (Ted) Hogg, P. Gonzalez, R.Fensham, Z. Zhang, J. Castro, N. Demidova, J.H. Lim., G. Allard, S.W. Running, A. Semerci, N. Cobb. 2010. *A Global Overview of Drought and Heat-Induced Tree Mortality Reveals Emerging Climate Change Risks for Forests*. Forest Ecology Management, 259 (4,5): 660-684.

Baxter, J. 2006. *Preparing for a very different world: Global warming will have a profound effect on this planet as temperatures rise and rivers dry up. If it is to be stopped, we must act now*. November 1, 2006 Edmonton Journal. Edmonton, AB.

Bell, J. and M. Threshow. 2002. *Air Pollution and Plant Life – Second Edition*. West Sussex, England.: John Wiley & Sons Ltd.

Beltaos, S. 2000. *Advances in River Ice Hydrology*. Hydrological Processes. 14. p. 1613-1625.

Boesch, D.F., R.B. Brinsfield and R.E. Magnien. 2001. *Chesapeake Bay Eutrophication: Scientific Understanding, Ecosystem Restoration, and Challenges for Agriculture*. Journal of Environmental Quality. 30. p. 303-320.

Boorman, D.B. 2003. *Climate, Hydrochemistry and Economics of Surface-Water Systems (CHESS): Adding a European Dimension to the Catchment Modelling Experience Developed Under LOIS*. Science of the Total Environment. 314-316. p. 411-437.

Boutin, S., F. Dalerum, P. McLoughlin and J. Dunford. 2006. *Lichen abundance in the peatlands of northern Alberta: Implications for boreal caribou*. Ecoscience Journal: 469-474.

Brady, N.C. and R.R. Weil. 2000. The Nature and Properties of Soils. 12th Edition. Prentice-Hall Inc. Saddle River, NJ. p. 324.

Brooks, J., L. Flanagan and J. Ehleringer. 1998. *Responses of Boreal Conifers to Climate Fluctuations: Indicators from Tree-ring Widths and Carbon Isotope Analysis*. Canadian Forestry Journal. 28: 524-533.

Burn, C.R. 2003. *Climate Change Scenarios for the Mackenzie Gas Project*. Internal paper, Indian and Northern Affairs Canada. 11 pp.

Burns, R.M. and B.H. Honkala 1990. *1: Silvics of North America; 2: Conifers*. In Hardwoods. U.S. Department of Agriculture, Forest Service. Washington DC. 887 pp

Chalecki, E.L. and P.H. Gleick. 1999. *A Framework of Ordered Climate Effects on Water Resources: a Comprehensive Bibliography*. Journal of the American Water Resources Association. 35. p. 1657-1665.

CICS (Canadian Institute for Climate Studies). 2005. http://www.cics.uvic.ca/ Accessed November 2005.

Cohen, S.J. 1995. *The Potential Effects of Climate Change in the Peace, Athabasca and Slave River Basins: a Discussion Paper*. Northern River Basins Study. Edmonton, AB.

Cohen, S.J. 1997a. *Mackenzie Basin Impact Study – Final Report – Summary of the Results*. Issued Under the Authority of the Minister of Environment, Minister of Supply and Services, Catalogue no. En 50-118/1997-1E, Ottawa, ON.

Cohen, S.J. 1997b. *What If and So What in Northwest Canada: Could Climate Change Make a Difference to the Future of the Mackenzie Basin?* Arctic. 50(4): 293-307.Doucet, J. 2004. Oil Sands Reclamation – Associated challenges and mechanisms ensuring compliance. University of Alberta. Edmonton, AB.

Cruise, J.F., A.S. Limaye and N. Al-Abed. 1999. *Assessment of Impacts of Climate Change on Water Quality in the Southeastern United States*. Journal of the American Water Resources Association. 35. p. 1539-1550.

Doucet, J. 2004. *Oil Sands Reclamation – Associated Challenges and Mechanisms Ensuring Compliance*. University of Alberta. Edmonton, AB.

Environment Canada. 2007 National Climate Data and Information Archive. Availableat:http://www.climate.weatheroffice.gc.ca/climateData/canada_e.html. Accessed November 28, 2007.

Environment Canada. 2012. *Products and Services, Water Data, Climate Data Online, Climate Normals and Averages*. Available online at: http://climate.weatheroffice.gc.ca/Welcome_e.html.

Environment Canada. 2013a. National Climate Data and Information Archive, Available at: http://www.climate.weatheroffice.gc.ca/climate_normals/index_e.html. Accessed January 15, 2013.

Environment Canada. 2013b. Quenching the Peace Athabasca Delta. Available at: http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=832CDC7B&xsl=articlesservices,viewfull&po=357EBE1F Accessed January 16, 2013.

Environmental Research and Studies Centre. 2007. *Running Out of Steam? Oil Sands Development and Water Use in the Athabasca River-Watershed: Science and Market Based Solutions*. University of Alberta. Edmonton, AB.

Fang, X. and H.G. Stefan. 1997. *Simulated Climate Change Effects on Dissolved Oxygen Characteristics in Ice-Covered Lakes*. Ecological Modelling. 103. p. 209-229.

Fang, X. and H.G. Stefan. 2000. *Projected Climate Change Effects on Winterkill in Shallow Lakes in the Northern United States*. Environmental Management. 25. p. 291-304.

Fang, X., H.G. Stefan and S.R. Alam. 1999. *Simulation and Validation of Fish Thermal DO Habitat in North-Central US Lakes Under Different Climate Scenarios*. Ecological Modelling. 118. p. 167-191.

Flanagan, K.M., E. McCauley, F. Wrona and T. Prowse. 2003. *Climate change: the potential for latitudinal effects on algal biomass in aquatic ecosystems*. Can. J. Fish. Aquat. Sci. 60: 635–639.

Frich, P., L.V. Alexander, P. La Marta, B. Gleason, M. Haylock, A. Klein-Tank and T. Peterson. 2001. *Observed Coherent Changes in Climatic Extremes During the Second Half of the 20th Century*. Climate Research. 19. 3.

Gear, A.J. and B. Huntley. 1991. *Rapid changes in the range limits of Scots pine 4000 years ago*. Science (Washington, D.C.), 251: 544–547; in Weber, M.G. and Flannigan M.D. 1997. Canadian boreal forest ecosystem structure and function in a changing climate: impact on fire regimes. Environ. Rev. 5: 145-166.

Girardin, M.P. 2008. *Response of tree growth to a changing climate in boreal central Canada: A comparison of empirical, process-based, and hybrid modelling approaches*. Ecological modelling, Vol. 213:2, p. 209-228.

Golder (Golder Associates Ltd.). 2005. *Monitoring Climate and Climate Change Impacts in the National Parks and Northern Bioregion*. Final Report. Calgary, AB. p. 3-11.

Gundersen, P., I.K. Schmidt and K. Raulund-Rasmussen. 2006. *Leaching of Nitrate from Temperate Forests — Effects of Air Pollution and Forest Management*. Environmental Reviews 14: 1–57.

Hogg, W.D. and D.A. Carr. 1985. *Rainfall Frequency Atlas for Canada*. Canadian Government Publishing Centre. Ottawa, ON.

Hostetler, S.W. and E. Small. 1999. *Response of North American Freshwater Lakes to Simulated Future Climates*. Journal of the American Water Works Association. 35. p. 1625-1638.

Hutjes, R.W.A., P. Kabat, S.W. Running, W.J. Shuttleworth, C. Field, B. Bass, M.A.F. da Silva Dias, R. Avissar, A. Becker, M. Claussen, A.J. Dolman, R.A. Feddes, M. Fosberg, Y. Fukushima, J.H.C. Gash, L. Guenni, H. Hoff, P.G. Jarvis, I. Kayane, A.N. Krenke, C. Liu, M. Meybeck, C.A. Nobre, L. Oyeband, A. Pitman, R.A. Pielke, M. Raupach, B. Saugier, E.D. Schulze, P.J. Sellers, J.D. Tenhunen, R. Valentini, R. Victoria and C.J. Vorosmarty. 1998. *Biospheric Aspect of the Hydrological Cycle*. Journal of Hydrology. 212-213. p. 1-21.

Interlandi, S.J. and C.S. Crockett. 2003. *Recent Water Quality Trends in the Schuylkill River, Pennsylvania, USA: A Preliminary Assessment of the Relative Influences of Climate, River Discharge and Suburban Development*. Water Research. 37. p. 1737-1748.

IPCC (Intergovernmental Panel on Climate Change). 2000. *Special Report on Emissions Scenarios*. N. Nakicenovic and R. Swart (ed.). Cambridge University Press. Cambridge, United Kingdom. 612 pp.

IPCC. 2001a. *Climate Change 2001: Synthesis Report. Contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. R.T. Watson (ed.). Cambridge University Press. Cambridge, United Kingdom. 397 p.

IPCC. 2001b. *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Chapter 9: Human Health. p. 453-485.

IPCC. 2005. The *IPCC Data Distribution Centre*. http://ipcc-ddc.cru.uea.ac.uk/ Accessed November 2005.

IPCC. 2007a. *Climate Change 2007: Synthesis report*. Contribution of working groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

IPCC. 2007b. *Fourth assessment report, Climate Change*. Working group II report: Impact, adaptation and vulnerability, chapter 1: Assessment of observed changes and responses in natural and managed systems. Available online at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm

Jamieson, N., R. Monoghan and D. Barraclough. 1999. *Seasonal Trends of Gross N Mineralization in a Natural Calcareous Grassland*. Global Change Biology 5: 423-431.

Jansen, W. and R.H. Hesslein. 2004. *Potential Effects of Climate Warming on Fish Habitats in Temperate Zone Lakes With Special Reference to Lake 239 of the Experimental Lakes Area (ELA), North-Western Ontario*. Environmental Biology of Fishes. 70. p. 1-22.

Jerabkova, L., C. Prescott and B. Kiskchuck. 2006. *Nitrogen Availability in Soil and Forest Floor of Contrasting Types of Boreal Mixedwood F*orests. Canadian Journal of Forest Research 36 (1): 112-122.

Kerr, J.A. 1997. *Future water levels and flows for Great Slave and Great Bear Lakes, Mackenzie River and Mackenzie Delta*. In: Cohen, S.J., ed. Mackenzie Basin Impact Study Final Report. North York: Environment Canada.

Körner, C. 1995. *Arctic and Alpine Biodiversity: Patterns, Causes, and Ecosystem Consequences*. Springer-Verlag, Berlin, Germany.

Li, C., M.D. Flannigan and I.G. Corns. 2000. *Influence of potential climate change on forest landscape dynamics of west-central Alberta*. Can. J. For. Res. 30: 1905-1912.

Loehle, C. 2003. *Competitive Displacement of Trees in Response to Environmental Change or Introduction of Exotics*. Environmental Management 32 (1): 106-115.

Luo Y. and X. Zhou. 2006. *Soil Respiration and the Environment*. Academic Press/ Elsevier, San Diego, CA, USA, pp328

Magnuson, J.J., K.E. Webster, R.A. Assel, C.J. Bowser, P.J. Dillon, J.G. Eaton, H.E. Evans, E.J. Fee, R.I. Hall, L.R. Mortsch, D.W. Schindler and F.H. Quinn. 1997. *Potential Effects of Climate Changes on Aquatic Systems: Laurentian Great Lakes and Precambrian Shield Region*. Hydrological Processes. 11. p. 825-871.

Malcolm, J.R., A. Markham, R.P. Neilson and M. Garaci. 2002. *Estimated migration rates under scenarios of global climate change*. Journal of Biogeography 29 (7), 835–849.

Markham, A. 1996. *Potential impacts of climate change on ecosystems: a review of implications for policymakers and conservation biologist*. Climate Research. 6: 179-191.

Maxwell, B., N. Mayer and R. Street. 1997. *The Canada Country Study: Climate Impacts and Adaptation - National Summary for Policy Makers*. Environment Canada. Ottawa, ON.

McKenney, D.W., J.H. Pedlar, K. Lawrence, K. Campbell and M.F. Hutchinson. 2007. *Potential Impacts of Climate Change on the Distribution of North American Trees*. BioScience, Vol. 57, No. 11 (December 2007), pp. 939-948.

Milly, P.C.D, K.A. Dunne and A.V. Vecchia. 2005. *Global pattern of trends in streamflow and water availability in a changing climate*. Nature 438: 347-350.

Moore, M.V., M.L. Pace, J.R. Mather, P.S. Murdoch, R.W. Howarth, C.L. Folt, C.Y. Chen, H.F. Hemond, P.A. Flebbe and C.T. Driscoll. 1997. *Potential Effects of Climage Change on Freshwater Ecosystems of the New England/Mid-Atlantic Region. Hydrologic Processes*. Hydrological Processes. 11. p. 925-947.

Murdoch, P.S., J.S. Baron and T.L. Miller. 2000. *Potential Effects of Climate Change on Surface-Water Quality in North America*. Journal of the American Water Resources Association. 36. p. 347-366.

Nakawatase, J. and D. Peterson. 2006. *Spatial Variability in Forest Growth – Climate Relationships in the Olympic Mountains, Washington*. Canadian Journal of Forestry Research 36: 77–91.

Natural Resources Canada. 2013. *Climate Change: Potential Impacts*. Available at: http://atlas.nrcan.gc.ca/site/english/maps/climatechange/potentialimpacts Accessed January 16, 2013.

Ozaki, N., T. Fukushima, H. Harasawa, T. Kojiri, K. Kawashima and M. Ono. 2003. *Statistical Analyses on the Effects of Air Temperature Fluctuations on River Water Qualities*. Hydrological Processes. 17. p. 2837-2853.

Peters R.L. and J.D. Darling. 1985. *The greenhouse effect and nature reserves*. BioSci 35(1):707-716; in Markham, A. 1996. Potential impacts of climate change on ecosystems: a review of implications for policymakers and conservation biologist. Climate Research. 6: 179-191.

Price, D.T., C.H. Peng, M.J. Apps and D.H. Halliwell. 1999. *Simulating Effects of Climate Change on Boreal Ecosystem Carbon Pools in Central Canada*. Journal of Biogeography 26: 1237-1248.

Prowse, T.D. and S. Beltaos. 2002. *Climatic Control of River-Ice Hydrology: a Review*. Hydrological Processes. 16. p. 805-822.

Qinfeng, G., J. Brandle, M. Schoeneberger and D. Buettner. 2004. *Simulating the Dynamics of Linear Forests in Great Plains Agroecosystems Under Changing Climates*. Canadian Journal of Forestry Research 34: 2564–2572.

Ramstack, J.M., S.C. Fritz and D.R. Engstrom. 2004. *Twentieth Century Water Quality Trends in Minnesota Lakes Compared With Presettlement Variability*. Canadian Journal of Fisheries and Aquatic Sciences. 61. p. 561-576.

Reed, F.N. 2001. *Beyond Kyoto: Forest Management in a Time of Rapid Climate Change Conservation Biology*. 15(3): 578–590.

Reist, J.D. 1994. *An Overview of the Possible Effects of Climate Change on Northern Freshwater and Anadromous Fishes*. S.J. Cohen (ed.). Environment Canada. Ottawa, ON. p. 377-385.

Rothman, D.S. and D. Herbert. 1997. *The socio-economic implications of climate change in the forest sector of the Mackenzie Basin*. In: Cohen, S.J., ed. Mackenzie Basin Impact Study Final Report. North York, Ontario: Environment Canada.

Rouse, W.R., M.S.V. Douglas, R.E. Hecky, A.E.Hershey, G.W. Kling, L.Lesack, P. Marsh, M. McDonald, B.J. Nicholson, N.T. Roulet and J.P. Smol. 1997. Effects of Climate Change on the Freshwaters of Artic and Subarctic North America. Hydrological Processes 11(8):379-902.

Rustad, L.E., J.L. Campbell, G.M. Marion, R.J. Norby, M.J. Mitchell, A.E. Hartley, J.H.C. Cornelissen, J. Gurevitch and GCTE-NEWS. 2001. *A Meta-Analysis of the Response of Soil Respiration, Net Nitrogen Mineralization, and Aboveground Plant Growth to Experimental Ecosystem Warming*. Oecologia 126: 543–562.

Scheller, R.M. and D.J. Mladenoff. 2005. *A Spatially Interactive Simulation of Climate Change, Harvesting, Wind, and Tree Species Migration and Projected Changes to Forest Composition and Biomass in Northern Wisconsin, USA*. Global Change Biology 11: 307–321.

Schindler, D.W. 1997. *Widespread Effects of Climatic Warming on Freshwater Ecosystems in North America*. Hydrological Processes. 11. p. 1042-1067.

Schindler, D.W. 2001. *The Cumulative Effects of Climate Warming and Other Human Stresses on Canadian Freshwaters in the New Millennium*. Canadian Journal of Fisheries and Aquatic Sciences. 58. p. 18-29.

Schlesinger, W.H. 1997. *Biogeochemistry, An Analysis of Global change*, Academic Press, 1997, pp. 159–163.

Shell (Shell Canada Limited). 2005. *Muskeg River Mine Expansion Project Supplemental Information*. Volume 1,2, 3 and 4. Prepared by Golder Associates Ltd. and Nichols Applied Management. Submitted to Alberta Energy and Utilities Board and Alberta Environment. Fort McMurray, AB.

Shimoda, Y., M.E. Azim, G. Perhar, M. Ramin, M.A. Kenney, S. Sadraddini, A. Gudimov and G. Arhonditsis. 2011. *Our current understanding on lake ecosystem response to climate change: what have we really learned from the north temperate deep lakes?* J. Great Lakes Res. 37, 173-193.

Shuter, J.B., C.K. Minns, and N. Lester. 2002. *Climate Change, Freshwater Fish, and Fisheries: Case Studies From Ontario and Their Use in Assessing Potential Impacts.* In Fisheries in a Changing Climate. Maryland, Bethesda. p. 77-88.

Stefan, H.G., M. Hondzo and X. Fang. 1993. *Lake Water Quality Modeling for Projected Future Climate Scenarios*. Journal of Environmental Quality. 22. p. 417-431.

Struyf, E., S. Van Damme and P. Meire. 2004. *Possible Effects of Climate Change on Estuarine Nutrient Fluxes: a Case Study in the Highly Nutrified Schelde Estuary (Belgium, The Netherlands)*. Estuarine, Coastal and Shelf Science. 60. p. 649-661.

Theurillat, J.P. and A. Guisan. 2001. *Potential Impact of Climate Change on Vegetation in the European Alps: A Review*. Climate Change, 50: 77-109.

Thomann, R.V. and J.A. Mueller 1987. *Principles of Surface Water Quality Modeling and Control*. Harper Collins Publisher. New York, NY.

Thompson, I.D., M.D. Flannigan, B.M. Wotton and R. Suffling. 1997. *The effects of climate change on landscape diversity: an example in Ontario forests*. Environ. Monit. Assess. In press; in Weber, M.G. and Flannigan M.D. 1997. Canadian boreal forest ecosystem structure and function in a changing climate: impact on fire regimes. Environ. Rev. 5: 145-166.

Von Finster, A. 2001. *Draft Discussion Paper, Possible Effects of Climate Change on the Physical Characteristics of Fish Habitats in the Yukon Basin in Canada*. Department of Fisheries and Oceans, Habitat and Enhancement Branch. Whitehorse, YK.

Walker, H.A., J.S. Latimer and E.H. Dettmann. 2000. *Assessing the Effects of Natural and Anthropogenic Stressors in the Potomac Estuary: Implication for Long-Term Monitoring*. Environmental Monitoring and Assessment. 63. p. 237-251.

Walker, K.V., M.B. Davis and S. Sugita. 2002. *Climate Change and Shifts in Potential Tree Species Range Limits in the Great Lakes Region*. Journal of Great Lakes Research 28: 555–567.

Weber, M.G. and M.D. Flannigan. 1997. *Canadian boreal forest ecosystem structure and function in a changing climate: impact on fire regimes*. Environ. Rev. 5: 145-166.

Worrall, F., W.T. Swank and T.P. Burt. 2003. *Changes in Stream Nitrate Concentrations Due to Land Management Practices, Ecological Succession, and Climate : Developing a Systems Approach to Integrated Catchment Response*. Water Resources Research. 39. 7.

Zhang, X., W.D. Hogg and E. Mekis. 2000a. *Spatial and Temporal Characteristics of Heavy Precipitation Events Over Canada*. Journal of Climate.

Zhang, X., L.A. Vincent, W.D. Hogg and A. Niitsoo. 2000b. *Temperature and Precipitation Trends in Canada During the 20th Century*. Atmosphere-Ocean. 38. p. 395-429.

Zhou, X., C. Peng, Q. Dang, J. Chen and S. Parton. 2005. *Predicting Forest Growth and Yield in Northeastern Ontario Using the Process-Based Model of TRIPLEX1.0*. Canadian Journal of Forestry Research 35: 2668-2280.

9 ABBREVIATIONS

%	Percent
>	More than
°	Degree
°C	Temperature in degrees Celsius
AAAQO	Alberta Ambient Air Quality Objectives
AENV	Alberta Environment
Cenovus	Cenovus FCCL Ltd.
CICS	Canadian Institute for Climate Studies
CO_2	Carbon dioxide
e.g.	For example
EIA	Environmental Impact Assessment
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/yr	Kilometres per year
km^2	Square kilometre
LSA	Local Study Area
m^3/d	Cubic metres per day
mm	Millimetre
mm/yr	Millimetres per year
N	Nitrogen
N	North
PAI	Potential Acid Input
ppb	Parts per billion
RSA	Regional Study Area

SAGD	Steam Assisted Gravity Drainage
spp.	Multiple species
SRES	Special Report on Emissions Scenarios
the Project	Christina Lake Thermal Project – Phase H and Eastern Expansion
TOR	Terms of Reference
WBEA	Wood Buffalo Environmental Association

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.
Anoxia	Little to no dissolved oxygen in the water sample. Waters with less than 2 mg/L of dissolved oxygen experience anoxia.
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.
Bioaccumulation	The accumulation of substances, including both toxic and benign substances, within the tissues of an organism.
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.
Biomass	The weight of living matter in a given area or sample.
Boreal Forest	The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.
Canopy	An overhanging cover, shelter or shade. The tallest layer of vegetation in an area. The uppermost layer in a forest, formed by the crowns of the trees.
Channel	The bed of a stream or river.
Chlorophyll a	One of the green pigments in plants. It is a photo-sensitive pigment that is essential for the conversion of inorganic carbon (e.g., carbon dioxide) and water into organic carbon (e.g., sugar). The concentration of chlorophyll a in water is an indicator of algal concentration.
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.
Ecosite	Ecological units that develop under similar environmental influences (climate, moisture and nutrient regime). Ecosites are groups of one or more ecosite phases that occur within the same portion of the moisture/nutrient grid. Ecosite is a functional unit defined by the moisture and nutrient regime. It is not tied to specific landforms or plant communities, but is based on the combined interaction of biophysical factors that together dictate the availability of moisture and nutrients for plant growth.
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.
Environmental Impact Assessment (EIA)	A review of the effects that a proposed development will have on the local and regional environment. Typically completed in accordance with a defined Terms of Reference (TOR).
Epilimnion	A freshwater zone of relatively warm water in which mixing occurs as a result of wind action and convection currents.
Evaporation	The process by which water is changed from a liquid to a vapour.
Evapotranspiration	A measure of the capability of the atmosphere to remove water from a location through the processes of evaporation and water loss from plants (transpiration).
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.
Geomorphology	The science of surface landforms and their interpretation on the basis of geology and climate. That branch of science that deals with the form of the earth, the general configurations of its surface and the changes that take place in the evolution of landforms.
Greenhouse Gases (GHGs)	Gases such as carbon dioxide (CO_2), water vapour, methane (CH_4), nitrous oxide (N_2O), and other trace gases which trap heat in the atmosphere, producing the greenhouse effect.
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.
Leaching	The removal, by water, of soluble matter from any solid material lying on top of bedrock (e.g., soil, alluvium or bedrock).
Littoral	The zone in a lake that is closest to the shore. It includes the part of the lake bottom, and its overlying water, between the highest water level and the depth where there is enough light (about 1% of the surface light) for rooted aquatic plants and algae to colonize the bottom sediments.

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.
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Organics	Chemical compounds, naturally occurring or otherwise, which contain carbon, with the exception of carbon dioxide (CO_2) and carbonates (e.g., $CaCO_3$).
Ozone (O_3)	A gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone in the upper atmosphere protects living organisms by preventing damaging ultraviolet light from reaching the Earth's surface. Ground-level ozone is an air pollutant with harmful effects on the respiratory systems of animals.
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.
Soil Horizon	A layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation. A soil mineral horizon is a horizon with 17% or less total organic carbon by weight. A soil organic horizon is a horizon with more than 17% organic carbon by weight.
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).
Terms of Reference	The Terms of Reference identify the information required by government agencies for an Environmental Impact Assessment.
Thermal Regime	The range in water temperature typically observed in a given waterbody.

Thermocline	A layer within a waterbody where the temperature changes rapidly with depth.
Trophic	Pertaining to part of a food chain, for example, the primary producers are a trophic level just as tertiary consumers are another trophic level.
Turbidity	An indirect measure of suspended particles, such as silt, clay, organic matter, plankton and microscopic organisms, in water.
Uplands	Areas that have typical ground slopes of 1 to 30% and are better-drainage.
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 entire surface drainage area that contributes water to a lake or river.
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.

APPENDIX 2-VI

MONITORING PROGRAMS

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

1 INTRODUCTION

Cenovus Energy Inc. (Cenovus) has committed to undertaking numerous monitoring programs in relation to the Christina Lake Thermal Project (CLTP), Phase H and Eastern Expansion (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 Lease area, including air quality, aquatic resources, terrestrial resources and social resources.

Cenovus has a comprehensive suite of monitoring programs currently in place for the CLTP. These monitoring programs will be expanded, as necessary, to encompass the Project. Cenovus 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. Cenovus will work with Alberta Environment and Sustainable Resource Development (ESRD) to design updated monitoring programs as necessary.

2 AIR QUALITY

Cenovus is committed to achieving regional air quality objectives through careful monitoring and regional management. Cenovus will monitor Project emission sources as required by the EPEA approval. In addition, Cenovus is a member of the following:

- Oil Sands Developers Group (OSDG) – Cenovus provides support and staff participation to the OSDG. Cenovus participates as a member and is also represented on its Board of Directors. The OSDG is funded through industry members and works with various other organizations to assess environment, social and economic effects of oil sands developments.
- Cumulative Environmental Management Association (CEMA) – CEMA is a multi-stakeholder forum established to design management systems to address cumulative effects of regional development in the RMWB in northeastern Alberta. Cenovus is an active participant in CEMA as well as its working groups who complete scientific and technical work related to the environment.
- Lakeland Industry and Community Association (LICA) – LICA is a multi-stakeholder partnership of community, industry and government supporting a sustainable environment and promoting responsible resource development. Cenovus is an active participant in LICA.

3 NOISE

The sound emission sources used in the noise assessment were a combination of measured data from similar equipment, data from vendors, and empirical formulae. This variation in data sources introduces an increased uncertainty that cannot be quantified.

The low consequence effect result predicted at Christina Lake Lodge and at "1.5 km Project Boundary; S" can be verified through periodic monitoring once operations begin.

Vendor-specific noise data will be reviewed when available. If needed, control mitigations will be designed during the detailed design stage and incorporated into the operational noise management plan. If vendor-specific noise data are not available, the equipment noise emission can be monitored during the as-built phase to validate the sound power levels used in the assessment.

4 AQUATIC RESOURCES

4.1 HYDROGEOLOGY

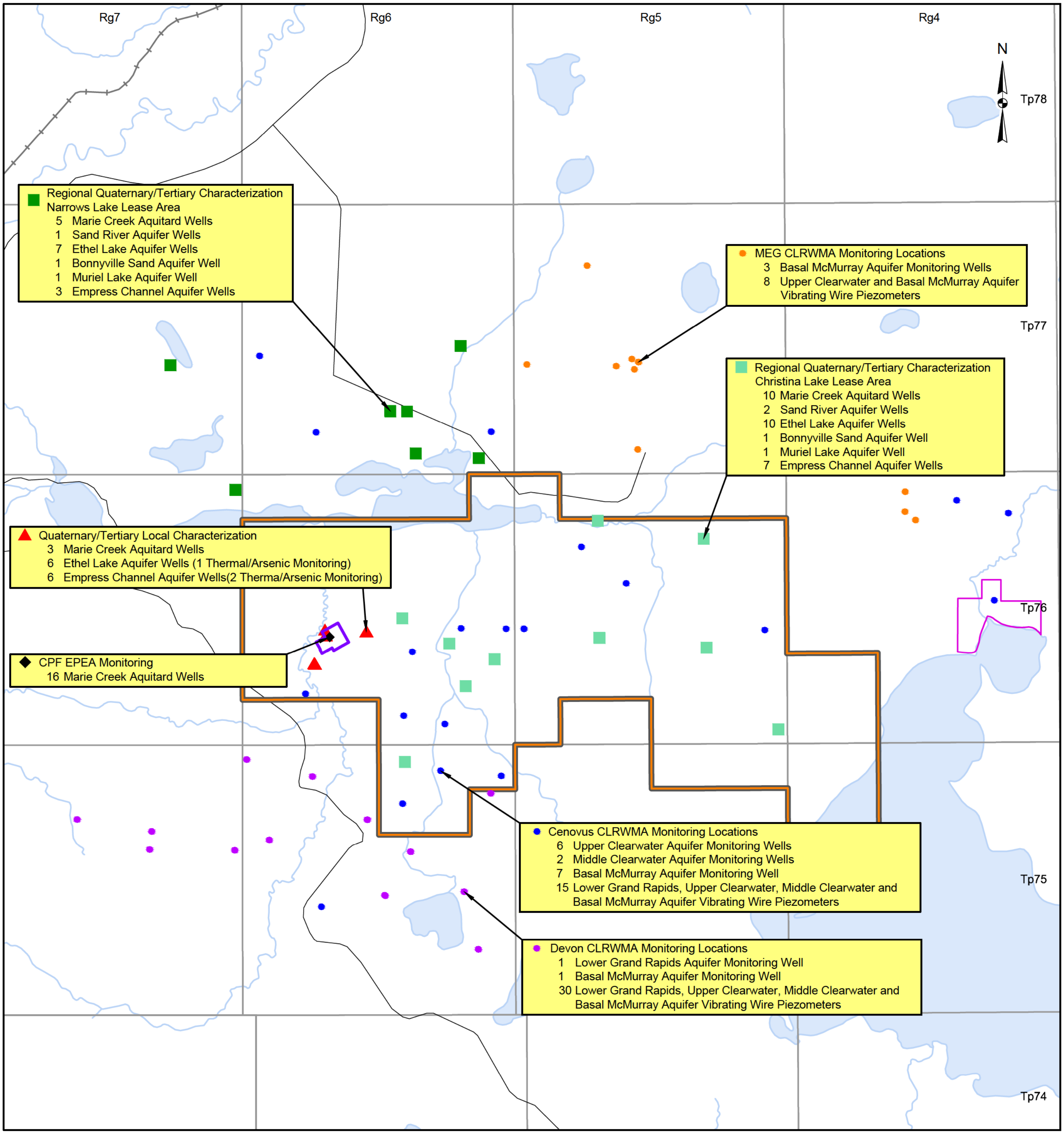
The goal of the monitoring program will be to detect changes in groundwater quality and quantity before potential negative effects to receptors arise. Groundwater monitoring will be carried out to facilitate the early detection and response to groundwater effects related to Project activities including:

- surface facility operations (including SAGD well drilling and completion);
- groundwater withdrawal and wastewater disposal; and
- steam injection (including the development of thermal plumes and steam generated heave effect).

This section describes the existing groundwater monitoring networks for each of the operation components. As operations expand, a more detailed groundwater monitoring plan will be generated in consultation with ESRD and approved prior to implementation. The groundwater monitoring plan will be consistent with the expectations outlined in the Lower Athabasca Region Groundwater Management Framework, and forthcoming groundwater monitoring directive (ESRD 2012).

In the event that groundwater monitoring identifies effects to groundwater quality or quantity, the groundwater response plan in Section 7.1.4 will be implemented.

In addition to the CLTP operational component monitoring wells (monitored as part of EPEA Approval 00048522-01-03), Quaternary and Tertiary aquifers have been monitored as part of the *Water Act* License (00082524-00-00) program for the Empress Channel Aquifer source wells (Figure 4.1-1). Additionally, camp water supply wells licenced under the *Water Act* are monitored according to the conditions contained in the related licence.



LEGEND

- Lease Area
- Indian Reserve
- CPF Location
- Railway
- Road
- Water Body / Watercourse

2 0 2

SCALE 1:200,000 KILOMETRES

PROJECT

cenovus ENERGY

CHRISTINA LAKE THERMAL PROJECT
PHASE H AND EASTERN EXPANSION

TITLE

CURRENT GROUNDWATER MONITORING LOCATIONS

Matrix Solutions Inc. ENVIRONMENT & ENGINEERING

PROJECT		-	FILE No.	3280-SP-12
DESIGN	AH	October 2012	SCALE AS SHOWN	REV. 0
CADD	ER	October 2012		
CHECK	SP	---	FIGURE: 4.1-1	
REVIEW	WW	---		

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004, 2005 AND 2006). USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 27 COORDINATE SYSTEM: UTM ZONE 12

*PLOT 1:1 = Letter (P)

F:\3280\Drafting\2012\3280-SP-12.dwg - GWM - Wednesday, January 02, 2013 10:20:27 AM - Edward Rugayan

Cenovus has also undertaken detailed delineation of the Quaternary and Tertiary sediments in the Christina Lake, Phase H Expansion, and Narrows Lake areas. The regional Quaternary/Tertiary characterization groundwater monitoring network includes 31 wells at 10 locations in the Christina Lake Lease Area, and 18 wells at 6 locations in the Narrows Lake Lease Area (Figure 7.1-1), completed in the following units:

- Marie Creek Aquitard;
- Sand River Aquifer;
- Ethel Lake Aquifer;
- Bonnyville Sand Aquifer;
- Muriel Lake Aquifer; and
- Empress Channel Aquifer.

4.1.1 Surface Facilities

Accidental releases from surface facilities could result in a decrease of the water quality in the shallow Quaternary sediments, and is considered a local, negative effect based on the assessment of Volume 4, Section 5.1.3 and Appendix 4-I. Groundwater monitoring in the Marie Creek Aquitard will serve as an early detection of changes to groundwater quality, allowing Cenovus to implement the groundwater response plan (Volume 4, Section 7.1.4), before water quality at surface waterbodies or existing water wells is affected.

The existing *Environmental Protection and Enhancement Act* (EPEA) approved plant site groundwater monitoring program is comprised of 16 monitoring wells completed in the Marie Creek Aquitard, ranging in total depth from 2.4 to 21.3 m bgs (Figure 4.1-1). The plant site monitoring wells serve to monitor background groundwater elevations and groundwater quality, in addition to monitoring for potential shallow effects to groundwater quality originating from process operations. 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. Baseline groundwater elevation and groundwater quality data has been collected at these monitoring wells since 2001 (Westwater 2012). Data from the groundwater monitoring program continues to provide information on groundwater levels, groundwater chemistry and potential changes to these related to the CLTP.

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. Groundwater samples are collected regularly from each monitoring well and field parameters, including water level, temperature, pH, and Electrical Conductivity (EC) are measured. Laboratory analyses on groundwater samples include:

- general water quality parameters and major ions;
- dissolved metals;
- benzene, toluene, ethylbenzene and xylenes (BTEX);
- F1 and F2 hydrocarbon fractions;
- total phenols;
- dissolved organic carbon (DOC);
- glycols; and
- naphthenic acids.

As the plant facility expands, the groundwater monitoring network will also expand as per additional EPEA amendments, and a detailed groundwater monitoring program proposal will be submitted to ESRD for review and approval prior to implementation. The groundwater monitoring network expansion will be consistent with the expectations outlined in the Lower Athabasca Region Groundwater Management Framework, and forthcoming groundwater monitoring directive (ESRD 2012).

4.1.2 Groundwater Withdrawal and Wastewater Disposal

Cenovus will responsibly manage groundwater usage by operating all wells as per the terms and conditions of associated groundwater diversion (*Water Act*) licenses or relevant ERCB requirements. In addition, Cenovus will responsibly manage the Project groundwater usage by:

- Monitoring and recording actual water usage from the Empress Channel, Middle Clearwater and the McMurray Aquifers.
- Monitoring and recording water level changes in selected aquifers near the groundwater source wells.
- Conducting periodic 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 review will include recommendations to further mitigate effects and/or improve monitoring.

- Collaborating with other SAGD operators in the region through initiatives such as the CLRWMA.

Monitoring of water levels in Quaternary and Tertiary units has been conducted for the water withdrawal from two Empress Channel Aquifer source wells at 09-17-076-06 W4M and will continue for the proposed Phase H expansion. In total, there are 15 non-pumping monitoring wells monitored and reported to ESRD to meet conditions of the *Water Act* approvals for these wells (Figure 4.1-1). The monitored Quaternary and Tertiary units include the Marie Creek Aquitard, and Ethel Lake and Empress Channel Aquifers. Three of these wells are also used for subsurface thermal plume monitoring for water quality (Volume 4, Section 7.1.3).

Water use volumes from the Middle Clearwater and Basal McMurray Aquifers are monitored over time and submitted as part of ERCB annual reporting for the existing CLTP. Additionally, a network of observation wells and vibrating wire piezometers are monitored over time for pressure by Cenovus. As shown in Figure 7.1-1, this network spans across the Christina Lake and Narrows Lake Lease Areas, and includes:

- 15 vibrating wire piezometers in the Lower Grand Rapids, Upper Clearwater, Middle Clearwater and Basal McMurray Aquifers;
- 4 monitoring wells screened in the Middle Clearwater Aquifer; and
- 7 monitoring wells screened in the Basal McMurray Aquifer.

Monitoring data from regional piezometers is shared between Cenovus, MEG and Devon as part of the CLRWMA. The existing groundwater monitoring wells and vibrating wire piezometers for CLRWMA industry parties is illustrated in Figure 4.1-1 and includes:

- 8 MEG vibrating wire piezometers in the Upper Clearwater and Basal McMurray Aquifers;
- 3 MEG monitoring wells screened in the Basal McMurray Aquifer;
- 30 Devon vibrating wire piezometers in the Lower Grand Rapids, Upper Clearwater, Middle Clearwater, Basal McMurray Aquifers;
- 1 Devon monitoring well screened in the Lower Grand Rapids; and
- 1 Devon Basal McMurray monitoring well.

Disposal wells will be drilled, completed and tested following all requirements outlined in ERCB *Directive 51: Injection and Disposal Wells* (ERCB 1994).

Each disposal well will be equipped with an appropriate meter for the service which is approved by ERCB *Directive 17: Measurement Requirements for Oil and Gas Operations* (ERCB 2011) measurement standards, a flow choke and a pressure recorder. The wellhead injection pressure and injection rate for each well will be monitored daily. The wells will be operated below the maximum wellhead pressure.

4.1.3 Steam Injection

The steaming process used in SAGD operations may heat sediments and water near the SAGD well bores. Changes to groundwater quality, including the liberation of arsenic, may result from the increase in temperature. The quantity and extent of heat migration and changes to groundwater quality in the vicinity of select well pads will therefore be monitored. The CLTP groundwater monitoring plan for subsurface thermal plumes incorporates information from three components:

- The existing Arsenic Monitoring Program comprises three wells completed in the Marie Creek Aquitard, Ethel Lake and Empress Channel aquifers, ranging in depth from 24.2 to 148.4 m bgs. This program was initiated at the first well pad constructed in 2001 to document pre-development conditions and to monitor changes in temperature. Trends of increasing arsenic concentrations have been identified in the Empress Channel Aquifer; however, these monitoring wells are located upgradient of the SAGD well pairs, and no corresponding increases in temperature have been observed in these monitoring wells (Westwater 2012).
- Plant site EPEA monitoring wells and additional local and regional Quaternary groundwater characterization program monitoring wells.
- The Thermal Effects investigation study site at the Foster Creek Thermal Project, described below.

Cenovus has initiated a detailed Thermal Effects Investigation Study Site at operating Well Pad G at the Foster Creek Thermal Project. The goals of the investigation at the Foster Creek Facility are to determine the thermal effects of SAGD operations on non-saline aquifers, and gain an understanding of the mechanisms for mobilization and precipitation of trace elements (particularly arsenic) for a typical production scheme (after steaming has occurred for several years). Once complete, the investigation findings will be used to assist in the development of appropriate groundwater monitoring programs for future SAGD developments or expansion.

The existing Arsenic Monitoring Program will continue to include water levels, temperature, and analysis of major ions and dissolved metals, including arsenic, in accordance with the Lower Athabasca Region Groundwater Management Framework. Based on the results of the Thermal Effects Investigation at Foster Creek, additional well pads may be chosen for thermal monitoring. Should significant changes in groundwater quality be detected, a groundwater response plan will be implemented (Volume 4, Section 7.1.4).

4.1.4 Groundwater Response Plan

The Groundwater Response Plan will be developed to meet the requirements of the Lower Athabasca Region Groundwater Management Framework, and forthcoming groundwater monitoring directive (ESRD 2012). The response plan will establish a logical sequence of activities that will be undertaken if a water quality or quantity trigger is exceeded during routine monitoring activities. Aspects of the plan may include:

- verifying analytical results;
- conducting confirmatory re sampling;
- assessing the results against the natural variations;
- investigating the extent of the effect; and
- initiating a groundwater management plan that may include remediation activities.

The Groundwater Response Plan will be submitted to ERSD for approval as part of the overall Groundwater Monitoring Program.

4.2 HYDROLOGY

4.2.1 Surface Disturbances

A surface water monitoring program including maintenance where and when required will be an integral part of Project operations. This program will continue until Project decommissioning and will include the following:

- Winter spot flow measurements to extend the baseline low-flow data which is currently limited to none. A surface water monitoring program will be in place before the construction of the Project, during operations, and after the decommissioning of the Project to collect information on winter low flows in selected watercourses. This program will be integrated with groundwater and wetlands monitoring programs.

- Regular monitoring of the stormwater ponds to confirm adequate storage capacity is available and to prevent uncontrolled releases from the plant site and well pad drainage systems. The downstream drainage path from the slow release lines will also be inspected annually to confirm that the terrain is absorbing the water with no apparent vegetation stress and that no downstream channel development or erosion is occurring. If required and practicable, remedial measures such as re-directing the drainage, extending or perforating release lines, incorporating bio-technical erosion control measures or re-vegetation efforts can be employed to correct potential areas of concern before they become a problem.
- Culvert installations at road crossings and wetlands areas will be monitored regularly, particularly during or following high runoff periods. 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 on each side of the access roads will be monitored to ensure that they remain equal on both sides.
- Re-graded areas will be inspected for evidence of erosion or instability, and repaired or stabilized as required. Revegetation efforts will be monitored and maintained to ensure growth and survival. Replanting will occur if survival of vegetation is inadequate.
- Drainage courses disturbed during construction will be inspected to ensure that riparian vegetation and stable drainage conditions have been re-established.

4.2.2 Watercourse Crossings

A monitoring program will be implemented to ensure that sediment generation caused by construction and operation of all watercourse crossings for the Project is kept to a minimum. The monitoring program will include the following:

- inspection of culverts to ensure proper operation;
- inspection of all watercourse crossings to ensure that properly installed sediment control measures are in place during and following construction; and
- post-construction inspection to ensure that affected streambed profiles and bank disturbances have been appropriately reclaimed.

4.3 WATER QUALITY

Water quality compliance monitoring will be an integral component of the Project operations.

Stormwater ponds will be tested before release to the surrounding environment to verify acceptability of release waters for parameters defined under the EPEA approval for the Project. For example, the EPEA Approval No. 48522-00-09 for the Christina Lake Thermal Project includes sampling for pH and chloride, and a visual assessment of the presence of oil and grease (Table 4.3-1).

Treated domestic wastewaters will be sampled and tested a minimum of three times per week to ensure that the effluent quality meets or exceeds the limits for treated wastewater discharge of 25 mg/L CBOD and 25 mg/L TSS, as required under the current EPEA Approval for the Christina Lake Thermal Project (Table 4.3-1).

Table 4.3-1 Water Quality Limits and Monitoring Parameters for an Industrial Control System at Christina Lake Thermal Project

Parameter	Concentration Limit	Frequency	
		Before Release	During Release
pH	6.0 to 9.5 pH unit	once	once/day
Oil and grease	No visible sheen	once	once/day
Chloride	500 mg/L	once	once/day

- = Not applicable.
Source: AENV (2003).

4.4 FISH AND FISH HABITAT

Based on the results of the analysis completed for Fish and Fish Habitat, monitoring programs are not planned outside those identified for groundwater, hydrology and water quality components. Should results of these monitoring programs indicate monitoring of aquatic biota is warranted, a program will be developed in consultation with regulators. The construction of watercourse crossings will be monitored in accordance with guidelines, as required.

5 TERRESTRIAL RESOURCES

Project effects will be monitored by Cenovus to provide feedback on the effects of development and mitigation activities on Terrestrial Resources. The monitoring programs will include assessments of the effects of development on wetlands and wildlife, as well as on the success of achieving reclamation goals for soils, vegetation, wildlife and biodiversity. These programs will be integrated into existing monitoring programs that are currently being implemented; both programs being conducted by Cenovus and regional monitoring programs that may be implemented in the future.

Cenovus will participate in relevant regional working groups and research programs to resolve uncertainties associated with developments in the area. Residual mitigation activities that may be recommended by these research programs will be reviewed for appropriateness regarding inclusion in the Project.

Regional wildlife and biodiversity monitoring required under the Project EPEA Approval will be conducted through established joint regional efforts. Currently, this monitoring is conducted by the Alberta Biodiversity Monitoring Institute and the Ecological Monitoring Committee for the Lower Athabasca, as supported by the Regional Terrestrial Monitoring Joint Working Group. Additional detail on these programs is provided in Volume 5, Section 1.7.4.

5.1 SOIL AND RECLAMATION

Future soils, vegetation and wetlands, wildlife habitats and biodiversity cannot be accurately predicted because the performance of the terrestrial ecosystem in the Far Future will depend on many factors (e.g., climate and management). The conceptual C&R Plan provides an estimate of the Far Future scenario as described in the post-reclamation mapping (Volume 1, Section 14). The plan includes upland and transitional wetlands reclamation procedures and starting vegetation planting prescriptions for the targeted post-reclamation ecosite phases. The objectives of the C&R monitoring program are to evaluate the success of the reclamation procedures and planting prescriptions in achieving the targeted ends, over time, and to adjust or modify these measures where necessary to ensure the following:

- erosion control and slope stability;
- revegetation and sustainability of all disturbed areas;
- weed control;
- re-establishment of wildlife habitat;

- restoration of biodiversity; and
- reclamation certification.

The monitoring objectives will be met through regular site inspections, additional reclamation efforts over time (if necessary), evaluation of the monitoring program results on all reclaimed areas, and extrapolation of data from other projects. Reclamation monitoring will be integrated with other relevant monitoring programs.

Cenovus will produce an annual C&R report summarizing the previous year's activities, which includes some or all of the following:

- completed reclamation activities;
- completed assessments conducted on proposed facility areas to be constructed in the following year (i.e., PDAs);
- results of reclamation monitoring; and
- planned activities for the following year.

This report will be submitted to ESRD in accordance with the terms and conditions of the Project approval.

5.2 TERRESTRIAL VEGETATION, WETLANDS AND FOREST RESOURCES

Cenovus will implement a wetlands monitoring program similar to what has been developed for the CLTP (Golder 2012). The monitoring program will be designed to determine whether construction of Project Infrastructure and surface or groundwater withdrawls are affecting plant community structure, composition and function as indicated by changes in surface water levels and/or water chemistry; and to determine whether implemented mitigation measures are effective as indicated by the maintenance of wetland plant species composition, abundance and vigour (health).

Wetlands vegetation is monitored as an indicator of Project effects to wetlands ecosystems for several reasons. Wetlands contain a diverse assembly of plant species that tend to have rapid growth rates and respond directly to abiotic and biotic changes in the environment. In addition, plant communities in wetlands have been found to change in response to effects such as hydrologic changes, nutrient enrichment, sediment loading, metal deposition and other pollutants.

Wetlands vegetation monitoring sites will be selected to provide both baseline information and to monitor the potential effects of the Project. Baseline sites will be located in areas not affected by the Project. Project monitoring sites will be located in areas with the potential to be effected by the Project. For all monitoring sites, locations will be selected 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 connected to both surface and groundwater and are, therefore, more sensitive to changes in these parameters. Bog wetlands types are isolated from groundwater changes and only receive water via precipitation and runoff. As a result, more monitoring sites will be placed in fen, swamp and marsh wetlands types than in bog 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 (electrical conductivity, pH and total dissolved solids);
- 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.

Vegetation monitoring will be conducted in accordance with *2010 Reclamation Criteria for Wellsites and Associated Facilities for Forested Lands* (AENV 2010b). Cenovus acknowledges that these criteria were not specifically designed for oil sands developments, but feels that it is a robust tool that will provide effective monitoring and assessment in lieu of oil sands specific criteria. Should specific criteria be developed, Cenovus will adopt these monitoring techniques on the CLTP.

5.3 WILDLIFE

Cenovus will implement a wildlife monitoring program associated with the Project that will mirror the current CLTP Approved Wildlife Monitoring Plan. The monitoring program will include surveys to assess wildlife effects from the Project and the effectiveness of mitigation strategiesThirteen specific objectives that will be monitored (as taken from the CLTP Wildlife Monitoring Plan, Golder 2012a) include:

- minimizing or eliminating vehicle-wildlife collisions;
- minimizing bird/bat collisions with Project infrastructure;
- minimizing noise generated by Project infrastructure and activities;
- minimizing light generated by Project infrastructure and activities;
- increasing wildlife awareness amongst workers at the Project;
- minimizing vehicle access on linear features within the Lease Area;
- minimizing bear-human conflict;
- minimizing direct habitat loss;
- minimizing direct impacts to wildlife during sensitive periods;
- minimizing short-term barriers to movement;
- minimizing barriers to wildlife movement associated with AGP;
- minimizing wildlife-processed affected water interactions; and
- initiating progressive reclamation.

Additional wildlife monitoring will be undertaken to look at the effects of sensory disturbance on breeding birds and wildlife/community responses to development.

Information on the targets, metrics and monitoring of the above objectives can be found in the CLTP Wildlife Monitoring Program (Golder 2012a).

A wildlife log and sighting cards will be maintained at the plant sites and the camp to allow staff to record wildlife observations (e.g., sighting, call, nest, den, interactions with stormwater pond or facilities). The wildlife log will also be used to record any potential nuisance wildlife problems related to beavers and bears, and will be reported to ESRD. Personnel will be required to report all vehicle-wildlife collisions. Records will be summarized annually.

To assess the effects of barriers to wildlife movement, monitoring will include surveys of wildlife tracks and wildlife presence in relation to above-ground pipeline crossing structures to evaluate if movements are being affected and to determine the effectiveness of the mitigation measures employed. Monitoring will include winter track counts and photographic monitoring along the AGP. 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. Roads will also be monitored for wildlife road kill. Mortality logs will be kept to check for trends. Any woodland caribou deaths or injuries will be reported to ESRD.

Cenovus is working collaboratively with other in-situ operators to develop a coordinated approach to wildlife monitoring in the region. The basis for this approach is that the various companies have similar project Alberta *Environmental Protection and Enhancement Act* (EPEA) approval conditions related to wildlife monitoring and there is value in coordinating the monitoring efforts.

As part of this coordinated approach, Cenovus anticipates there will be full sharing of information amongst all in-situ operators concerning their local, project-specific wildlife monitoring, as well as coordination of regional wildlife monitoring efforts.

Cenovus recognizes the importance of long-term, large-scale monitoring of a wide range of taxa to measure changes in wildlife relative abundance that may result from anthropogenic disturbances. The Alberta Biodiversity Monitoring Program (ABMI) conducts world class monitoring of more than 2000 species and habitats to support decision making about provincial biodiversity. Cenovus will continue to fund and collaborate with other oil sands developers and support the regional ABMI to contribute to the monitoring of potential cumulative effects on wildlife in the region. Cenovus also supports the initiatives of the EMCLA for the LARP and will continue to fund and provide a committee member in regional initiatives for the Sustainable Ecosystems Working Group (SEWG) of CEMA.

Cenovus will also implement a caribou monitoring program associated with the Project that will mirror the current CLTP Approved Woodland Caribou Mitigation and Monitoring Plan. The monitoring program will include surveys to assess wildlife effects from the Project and the effectiveness of mitigation strategies. Eleven specific objectives that will be monitored (as taken from the CLTP Woodland Caribou Mitigation and Monitoring Plan, Wildlife Infometrics 2013) include:

- minimizing barriers associated with above ground infrastructure;

- minimizing temporary barriers to movement;
- minimizing human and predator access on legacy features;
- minimizing human and predator access on low use operational linear features;
- maximizing use of low-footprint seismic;
- minimizing the number of caribou-vehicle collisions;
- avoiding caribou habitat;
- maintaining caribou habitat;
- caribou habitat restoration;
- minimizing noise generated by the project; and
- minimizing light generated by the project.

Additional caribou monitoring will be undertaken to determine if applied mitigation activities and actions could be more effective at providing crossing opportunities in areas with AGP and discouraging or eliminating human and predator use of linear features,

Important foraging areas within the CLTP area will be inventoried and mapped to identify caribou specific constraints which could be used in the planning stages of future projects. Additionally, monitoring will be completed to determine if applied mitigation activities and actions aimed at restoring caribou habitat are effective.

Information on the targets, metrics and monitoring of the above objectives can be found in the CLTP Woodland Caribou Mitigation and Monitoring Plan (Wildlife Infometrics 2013).

Cenovus will support caribou population monitoring and research initiative of the ESAR and Cold Lake caribou herds in collaboration with ESRD and regional stakeholders as part of the Joint Canada Alberta Oil Sands Monitoring (Wildlife Infometrics 2013). Cenovus has also commited to working with other industrial neighbours and the provincial government as partners to establish adaptive management focal areas as a basis for monitoring over long periods of time and over large areas(Wildlife Infometrics 2013).

Cenovus will align the Phase H and Eastern Expansion wildlife monitoring program and woodland caribou monitoring plan with its Cenovus Operations Management System (COMS). The COMS represent a broad, enterprise-wide approach incorporating and integrating all relevant organizational business activities. The goal of COMS is to provide Cenovus with the management system design, content and continuous improvement activities needed to achieve strategic business objectives.

The COMS is a system of standards, controls and procedures that are being implemented to establish methods for consistently applying current best practices and incorporating new thinking to achieve the highest safety, environmental and operating performance.

The foundation of the COMS framework is based on a continuous improvement process defined as *Plan, Execute, Review and Improve* (PERI). Adaptive management principles associated with wildlife mitigation and monitoring will be incorporated into the PERI process.

Cenovus is committed to "operating responsibly" within the COMS framework to ensure the following requirements and expectations are met:

- **Regulatory Compliance Requirement:** Cenovus plans and conducts Operations activities in a manner that complies with jurisdictional legal and regulatory requirements.
- **Environmental Performance Requirement:** Cenovus Operations integrate processes that identify, evaluate, and establish objectives to manage environmental risk and meet environmental performance objectives.

Following the COMS adaptive management framework, any proposed changes to Cenovus's mitigation and monitoring programs will be forwarded to ESRD.

COMS expectations for environmental performance has already been incorporated in the implementation, monitoring and reporting of the CLTP Wildlife Mitigation and Monitoring Program (Golder 2012a).

Cenovus will consult with ESRD to ensure the proposed program meets the terms and conditions of the EPEA approval for the Project. All of Cenovus's monitoring information will be provided to ESRD to support regional wildlife management efforts.

5.4 BIODIVERSITY

Soils, vegetation and wildlife tend to be assessed separately rather than in an integrated manner (AENV 1999). However, ecosystems are connected through a steady flow of energy, nutrients and species (Noss 1983). Therefore, it is also important to assess integrated effects to biodiversity at the landscape and other levels to encompass key interacts between organisms and ecosystems. A biodiversity monitoring program will be developed to monitor the success of reclamation and establishment of biodiversity by integrating different ecosystem components for the Project based, in part, on the framework described in *Evaluation of the Alberta Biodiversity Monitoring Institute for Monitoring Reclaimed Oil Sands Sites* (Jaremko). The monitoring approach will build on the existing wildlife and biodiversity monitoring plan, which considers protocols established by the Alberta Biodiversity Monitoring Institute (ABMI; formerly Alberta Biodiversity Monitoring Program [ABMP]) to evaluate biodiversity in the province, with modifications to address project-specific requirements (Golder 2007). Biodiversity monitoring protocols might include winter track counts, breeding bird surveys, vegetation surveys and incidental wildlife observations (Alberta Biodiversity Monitoring Program [ABMP] 2006). Plot design for surveys will be consistent with the ABMI where those protocols are recommended. Under the LARP, a biodiversity management framework for the Lower Athabasca Region is to be developed by the end of 2013, along with a landscape management framework that will address restoration of linear disturbances (Government of Alberta 2012). The biodiversity management framework will set targets or thresholds for selected biodiversity indicators (vegetation, aquatic, wildlife) and address caribou habitat needs in alignment with provincial caribou policy (Government of Alberta 2012); these targets, thresholds and policies will be incorporated into the monitoring approach as appropriate.

Biodiversity indicators, as assessed in the EIA, could be measured and compared to reference sites within the region to determine whether these goals are being met. The use of established monitoring protocols ensures consistency and replicability over time within the Project LSA. Cenovus will work with other oil and gas and government partners in evaluating, and potentially conducting research and monitoring of cumulative environmental effects of oil and gas development in the region. In addition, Cenovus provided funding to the ABMI from 2010 to 2012.

6 SOCIO-ECONOMIC

No quantitative socio-economic monitoring programs are proposed for the Project. Cenovus will monitor the effects of its operations continually through ongoing effective engagement and consultation with stakeholders and Aboriginal groups, so that the information can be used to adjust policies, procedures, mitigation and enhancement measures and behaviours where deemed necessary. Cenovus's use of local community relations advisors who reside in the area has been successful in monitoring issues and service shortfalls in the communities where it operates. The local advisors are able to review and respond to issues in real time and also participate in community based organizations where information is exchanged, and joint initiatives are worked on, on an ongoing basis. Results of monitoring will also be discussed with nearby populations, as part of ongoing consultation and information exchange on the Project. In addition, Cenovus will co-operate with community stakeholders, other developers in the area, and the RCMP to monitor the traffic situation on Highway 881.

Adaptive management strategies aimed at addressing emerging issues throughout Project construction and operations will be employed. These strategies will be informed by ongoing evaluation of the effectiveness of mitigation and benefit enhancement measures. Cenovus plans to conduct stakeholder surveys every two years to gather feedback regarding areas of strength and potential areas of improvement relating to Cenovus's relationship with local stakeholders. These surveys will inform adaptive management strategies over time.

Cenovus will also be working with industry partners in the area (i.e., as members of the South Athabasca Oilsands Producers group) to understand if there are industry-wide trends and issues that need to be addressed either through additional mitigations or by government agencies.

7 REFERENCES

Alberta Health and Wellness. 2000a. *The Alberta Oil Sands Community Exposure and Health Effects Assessment Program: Methods Report. Edmonton Health Surveillance*. Prepared by a Consortium of Government, University and Corporate Partners. Edmonton, AB.

Alberta Health and Wellness. 2000b. *The Alberta Oil Sands Community Exposure and Health Effects Assessment Program: Summary Report*. Edmonton Health Surveillance. Prepared by a Consortium of Government, University and Corporate Partners. Edmonton, AB.

Alberta Health and Wellness. 2000c. *The Alberta Oil Sands Community Exposure and Health Effects Assessment Program: Technical Report*. Edmonton Health Surveillance. Prepared by a Consortium of Government, University and Corporate Partners. Edmonton, AB.

ASRD (Alberta Sustainable Resource Development). 2006. *The General Status of Alberta Wild Species 2005*. Alberta Sustainable Resource Development, Fish and Wildlife Service Division. Edmonton, AB.

CEMA (Cumulative Environmental Management Association). 2004. *Recommendations for the Acid Deposition Management Framework for the Oil Sands Region of North-Eastern Alberta*. Final Approved – February 25, 2004.

CEMA. 2006. *Ozone Management Framework for the Regional Municipality of Wood Buffalo Area*. Submitted April 2006.

Coppedge, B. R., D. M. Engle, R. E. Masters and M. S. Gregory. 2006. *Development of a grassland integrity index based on breeding bird assemblages*. Environmental Monitoring and Assessment. 118: 125-145.

EUB (Alberta Energy and Utilities Board). 1994. *Directive 051: Injection and Disposal Well - Well Classifications*, *Completions, Logging and Testing Requirements*. (March 1994). Calgary, AB. 42pp.

Golder. 2004. *Christina Lake Thermal Project. Wildlife and Wetlands Monitoring: Year 2*. Prepared for EnCana Corporation. Calgary, AB. 106 pp. + Appendices.

Golder. 2007. *MEG Energy Corporation Christina Lake Regional Project Phase 2 Wildlife and Biodiversity Monitoring Programs*. Submitted to Alberta Environment and Alberta Sustainable Resource Development. Prepared by Golder Associates Ltd.

Halsey, L. A., D. H. Vitt, D. Beilman, S. Crow, S. Mehelcic and R. Wells. 2003. *Alberta Wetland Inventory Classification System Version 2.0*. Alberta Sustainable Resource Development, Edmonton, AB. 54 pp.

Leskiw, L. A. 1998. *Land Capability Classification for Forest Ecosystems in the Oil Sands Region, Revised Edition*. Prepared for Tailing Sand Reclamation Practices Working Group. 93 pp.

Matrix (Matrix Solutions Inc.). 2007. *MEG Energy Corp Christina Lake Regional Project Phase 2 Wetlands Monitoring Program Proposal*. Submitted to Alberta Environment. Report prepared for MEG Energy Corp. Prepared by Matrix Solutions Inc.

Province of Alberta 2002. *Weed Control Act, Alberta Regulation 171/2001, Weed Regulation*. Alberta Queen's Printer. Edmonton, AB. 14 pp.

Roberge, J. and P. Angelstam. 2004. *Usefulness of the umbrella species concept as a conservation tool*. Conservation Biology 18: 76-85.

RWG (Reclamation Working Group). 2004. *Landscape Design Checklist. Designing Landscapes Right from the Start*. Cumulative Environmental Management Association, Reclamation Working Group, Landscape Design Subgroup. Fort McMurray, AB. Submitted April 19 2004. 14 pp.

Sergio, F., I. Newton, L. Marchesi and P. Pedrini. 2006. *Ecologically justified charisma: preservation of top predators delivers biodiversity conservation*. Journal of Applied Ecology 43: 1049-1055.

Snaith, T. and K. Beazley. 2002. *Moose (Alces alces Americana) as a focal species for reserve design in Nova Scotia, Canada*. Natural Areas Journal 22: 226-231.

Stevens, C., G. Scrimgeour, W. Tonn, C. Paszkowski, M. Sullivan and S. Millar. 2006. *Development and testing of a fish-based index of biological integrity to quantify the health of grassland streams in Alberta*. Technical report (T-2006-001) produced by Alberta Conservation Association. Edmonton, AB. 50 pp.

Takats, D. L., C. M. Francis, G. L. Holroyd, J. R. Duncan, K. M. Mazur, R. J. Cannings, W. Harris and D. Holt. 2001. *Guidelines for Nocturnal Owl Monitoring in North America*. Beaverhill Bird Observatory and Bird Studies Canada. Edmonton, AB. 32 pp.

TMAC (Trace Metals and Air Contaminants Working Group). 2002. *Recommendations on Trace Metals Management. Trace Metals and Air Contaminants Working Group, Cumulative Environmental Management Association*. Final – November 2001; Approved – May 2002.

WBEA (Wood Buffalo Environmental Association). 2007. Human *Exposure Monitoring Program. Part I - Methods Report. Part II - 2005 Monitoring Year Results*. Fort McMurray, AB.

Westwater. 2008. *2007 Groundwater Monitoring Report*. Alberta Environmental Protection and Enhancement Approval No. 48522-00-08. Christina Lake Thermal Project. Prepared for EnCana FCCL Oil Sands Ltd. March 2008.

7.1 INTERNET SITES

ABMP (Alberta Biodiversity Monitoring Program). 2009. Alberta Biodiversity Monitoring Institute Website. Available at: http://www.abmp.arc.ab.ca. Accessed on June 2009.

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