MEG Energy Corp.

Road Map of Christina Lake Regional Project - Phase 3

Application

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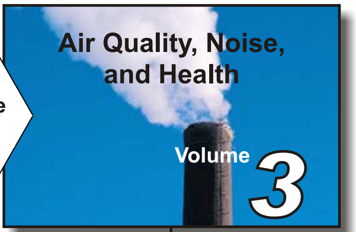

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1 AIR QUALITY ASSESSMENT

1.1 INTRODUCTION

MEG Energy Corp. (MEG) is a Calgary-based, privately held energy company focused on the development and recovery of bitumen, shallow gas reserves and the generation of power in northeast Alberta. MEG's Christina Lake Regional Project (CLRP) consists of 80 sections of oil sands leases within the Regional Municipality of Wood Buffalo (RMWB) in northeastern Alberta, approximately 15 km southeast of Secondary Highway 881 and 20 km northeast of Conklin.

MEG currently has approval to construct and operate the first two phases of the CLRP over 23 sections of land. In addition, MEG is developing a facility expansion (Phase 2B) to increase the production capacity of the Central Plant to 60,000 barrels per day (bpd). The Phase 2B plant will be located immediately adjacent to the existing Phase 1 and 2 processing facilities.

MEG is now proposing a further expansion of the CLRP to fully develop its Christina Lake oil sands leases. The Christina Lake Regional Project – Phase 3 (the Project) is an expansion of the current CLRP development area and will use Steam Assisted Gravity Drainage (SAGD) bitumen recovery technology. The Project will consist of two additional processing facilities (Plants 3A and 3B), 138 SAGD multi-well pads and associated steam generating equipment. Plant 3A will be located in the southeast corner of the lease (Sections 20 and 29-76-4 W4M); and Plant 3B will be located in the northwest end of the lease (Sections 32 and 33-77-6 W4M).

Construction of the Project is proposed to occur in two phases. Phase 3A is anticipated to begin construction in 2010, with initial steam injection in 2012. Phase 3B is anticipated to begin construction in 2012, with initial steam injection in 2014. The operational life of each plant is expected to be 25 years. Total production from the two new plants will produce an incremental 150,000 bpd of bitumen (approximately 23,800 cubic metres per day). It is anticipated that reclamation of the Project will be complete by 2044.

1.1.1 Overview

The objective of the air quality assessment is to identify and analyze the potential effects on air quality associated with the Project. Since the Project will be located in an airshed that contains other sources of air emissions, a regional air quality assessment was conducted that considers the combined operation of all of the existing, approved and planned activities in the region, including oil sands operations, other industrial operations and community activities.

The information included in the air quality component of the EIA is based on input from Alberta Environment (AENV) and regional stakeholders. The air quality assessment focuses on determining changes to the chemical composition of the air (Sections 1.5 to 1.8). The effects of changes in air quality and deposition to the receiving environment have been completed in the following sections: Environmental Health (Section 3) and Air Emissions Effects on Ecological Receptors (Section 4).

1.1.2 MEG's Commitment to Air Quality Management

MEG is committed to ensuring regional air quality objectives are achieved through careful monitoring and regional management. MEG has applied for membership in the following two regional air quality management initiatives related to the Project:

- Wood Buffalo Environmental Association (WBEA). The WBEA is a dynamic collaboration of communities, industry and government within the Regional Municipality of Wood Buffalo (RMWB). The WBEA consists of four key activities that are described as follows:
    - Regional Air Monitoring Network. The Regional Air Monitoring Network currently comprises thirteen monitoring stations equipped with several continuous air monitoring instruments. The purpose of this program is to monitor the ambient environment and produce monitoring results within the RMWB.
    - Terrestrial Environmental Effects Monitoring (TEEM) Program. The TEEM Program is designed to detect possible changes in soil chemistry and tree growth resulting from acid deposition, as well as to monitor certain other indicators of environmental stress. This program includes collection and review of data from a series of cyclical monitoring activities that are undertaken at annual or five-year intervals.
    - Human Exposure Monitoring Committee (HEMC). The WBEA formed the HEMC in late 2002 with a mandate to develop and implement a strategy and program for ongoing human exposure monitoring in the Oil Sands Region. The decision to form a committee within WBEA followed from the results of the Alberta Oil Sands Community Exposure and Health Effects Assessment Program (AOSCEHEAP), completed in 1997, through which continued monitoring was recommended. The activities of AOSCEHEAP were documented in a series of reports issued by

Alberta Health and Wellness (2000a,b,c). In 2005, the HEMC completed exposure monitoring in Fort McMurray and Fort Chipewyan (WBEA 2007). Plans are also being assembled by the committee to branch out monitoring studies to other communities. The HEMC is being implemented as a partnership of regional, provincial and national health authorities and the WBEA.

  - Communications Committee. The mandate of the Communications Committee is to develop a plan to create awareness of the WBEA in the community. The focus of the work is to connect with students and youth, as well as to promote an advertising campaign aimed at enhancing recognition of the WBEA in the community at large.

- 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 Regional Municipality of Wood Buffalo (RMWB) in northeastern Alberta. The Regional Sustainable Development Strategy (RSDS), an AENV initiative closely aligned to CEMA, provides a regulatory ‘backstop’ by which stakeholders can make recommendations to regulators on the management of cumulative effects. Currently, CEMA has several working groups, two of which are specific to air issues. These include:

  - The NO_X SO_2 Management Working Group (NSMWG), whose mandate is to develop a management plan (system) for oxides of nitrogen ($NO_{X)}$ and sulphur dioxide (SO_2) emissions as they relate to acidification and eutrophication, as well as ground-level ozone. In 2004, an acidification management plan (CEMA 2004) was endorsed by the Alberta Government based on recommendations from CEMA members. In 2006, the NSMWG also developed the Ozone Management Framework for the Regional Municipality of Wood Buffalo Area (CEMA 2006) that is based on the federal and provincial ozone frameworks.
  - The Trace Metals and Air Contaminants Working Group (TMAC), whose mandate is to assess the risks posed by trace metals and air contaminants to human health and ecosystems under existing environmental management systems. In 2002, TMAC issued recommendations for trace metals management, which were endorsed by the Alberta Government (TMAC 2002).

A summary of MEG’s air monitoring commitments is presented in Volume 2, Appendix 2-V.

1.1.2.1 Project Air Quality Management Initiatives

The Project has incorporated compliance with all of the relevant provincial and federal emissions guidelines into the process design and equipment selection. A summary of this is provided below:

- the new steam generators and heaters at the Project will use low NO_x burners and will be in compliance with Canadian Council of Ministers of the Environment (CCME) *National Emission Guidelines for Commercial/Industrial Boilers and Heaters* (CCME Website 1998), where applicable;
- sulphur recovery equipment will be installed as part of the project to minimize SO2 and acidifying emissions. Equipment will be designed to meet the ERCB sulphur recovery guidelines (EUB ID 2001-3);
- flaring will be minimized for the Project (e.g., upset/emergency conditions, start-up and commissioning) and continuous flaring will be limited to flaring at the MEG Central Plant Site, Plant 3A and Plant 3B;
- above-ground storage tanks will conform to *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Above Ground Storage Tanks* (CCME 1995); and
- the Project will establish a fugitive emissions management plan to identify and manage fugitive emissions sources.

1.2 AIR ASSESSMENT APPROACH

1.2.1 Component Description

The objective of the air quality assessment is to identify and analyze potential air effects associated with atmospheric emissions from the Project. Sources of air emissions at the Project include, but are not limited to:

- stationary combustion sources using natural gas and produced gas; and
- fugitive emissions sources at the facilities.

Dispersion models are used to predict ambient concentrations resulting from regional emission sources for each of the Existing and Approved, Project and Planned Development assessment cases. As recommended in the Project Terms of Reference (TOR) (AENV 2008), the regional emissions considered in the assessment include sulphur dioxide (SO_2), oxides of nitrogen (NO_X), carbon monoxide (CO), hydrogen sulphide (H_2S), particulate matter ($PM_{2.5}$), Volatile Organic Compounds (VOCs), Total Reduced Sulphur (TRS) compounds, Polycyclic Aromatic Hydrocarbons (PAHs) and airborne metals. The assessment also evaluates the effect of the Project emissions on acid deposition, or Potential Acid Input (PAI), in the region. In addition, the assessment discusses how the Project emissions could affect ground-level ozone (O_3) concentrations and odours in the region. Greenhouse Gas (GHG) emissions from the Project, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), are also considered in the air quality assessment.

1.2.2 Terms of Reference

This assessment was completed to meet the relevant TOR (AENV 2008) for the Project (Table 1.2-1) which state the following:

Table 1.2-1 Terms of Reference Concordance Table

TOR Section	Terms of Reference	Location TOR Addressed
3.7 **Air Emissions Management**	[A] Provide an emissions profile (type, rate and source) for the Project 's operating emission including point and non-point sources and fugitive emissions, and for construction emissions. Consider both normal and upset conditions. Discuss the following: (a) odorous or visual emissions from the proposed facilities;	(a) Volume 3, Section 1.8 Project Case
	(b) annual and total greenhouse gas (GHG) emissions for the life of the Project;	(b) Volume 3, Section 1.8 Project Case
	(c) the Project's contribution to total provincial and national GHG emissions on an annual basis;	(c) Volume 3, Section 1.8 Project Case
	(d) MEG's overall greenhouse gas management plans;	(d) Volume 3, Section 1.8.8.2 Approach to Managing Greenhouse Gases
	(e) the amount and nature of acidifying emissions, probable deposition patterns and rates;	(e) Volume 3, Section 1.6 Existing and Approved Case Volume 3, Section 1.8 Project Case Volume 3, Section 1.9 Planned Development Case Volume 3, Appendix 3-III Ambient Air Quality Predictions
	(f) control technologies used to minimize air emissions such as sulphur dioxide (SO_2), hydrogen sulphide (H_2S), oxides of nitrogen (NO_X), volatile organic compounds (VOC) and particulate matter;	(f) Volume 3, Section 1.1.2 MEG's Commitment to Air Quality Management
	(g) emergency flaring scenarios (e.g., frequency and duration) and proposed measures to ensure flaring events are minimized;	(g) Volume 3, Appendix 3-IV Upset Conditions
	(j) fugitive emissions control technologies to detect, measure and control emissions and odours from equipment leaks.	(j) Volume 3, Section 1.1.2 Project Air Quality Management Initiatives

Table 1.2-1 Terms of Reference Concordance Table (continued)

TOR Section	Terms of Reference	Location TOR Addressed
4.1.5 Modelling	[A] For each model used in the in the assessment scenarios, provide: (a) a justification for the model used. Air quality modelling should be conducted in accordance with the latest edition of the Air Quality Modelling Guidelines published by Alberta Environment; (b) a documentation of the assumptions used to obtain the modelling predictions; and (c) a discussion of the limitations of the models used and how these limitations were addressed, including sources of error and relative accuracy.	[A] Volume 3, Appendix 3-II Air Modelling Methods, Section 2 Modelling Methods
4.2 Climate, Air Quality and Noise		
4.2.1 Baseline Information	[A] Discuss baseline climatic and air quality conditions in the area including the following: a) the type and frequency of meteorological conditions that may result in poor air quality; and	a) Volume 3, Appendix 3-I Existing Air Quality and Meteorology
	b) appropriate ambient air quality parameters such as SO_2, H_2S, total hydrocarbons (THC), NO_X, VOC, individual hydrocarbons of concern in the THC and VOC mixtures, ground-level ozone (O_3), visibility, representative heavy metals and particulates (road dust, PM_{10} and $PM_{2.5}$).	b) Volume 3, Appendix 3-I Existing Air Quality and Meteorology
4.2.2 Impact Assessment	[A] Identify components of the Project that will affect local and regional air quality, and	[A] Volume 3, Appendix 3-II Air Modelling Methods, Section 3.1.1 MEG Project Emissions in the Project Case
	(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;	(a) Volume 3, Section 1.8 Project Case
	(b) estimate ground-level concentrations of appropriate air quality parameters;	(b) Volume 3, Section 1.6 Existing and Approved Case Volume 3, Section 1.8 Project Case Volume 3, Section 1.9 Planned Development Case Volume 3, Appendix 3-III Ambient Air Quality Predictions
	(c) discuss any expected changes to particulate deposition or acidic deposition patterns; (d) identify areas that exceed Potential Acid Input (PAI) critical loading criteria;	(c), (d) Volume 3, Section 1.6 Existing and Approved Case Volume 3, Section 1.8 Project Case Volume 3, Section 1.9; Planned Development Case Volume 3, Appendix 3-III Ambient Air Quality Predictions

Table 1.2-1 Terms of Reference Concordance Table (continued)

TOR Section	Terms of Reference	Location TOR Addressed
4.2.2 Impact Assessment (continued)	(e) discuss interactive effects that may occur as a result of co-exposure of a receptor to all emissions; and	(e) Volume 3, Section 1.8 Project Case
	[D] Describe how air quality and noise impacts resulting from the Project will be mitigated.	[D] Volume 3, Section 1.1.2.1 Project Air Quality Management Initiatives
	[E] Describe the residual air quality and noise effects of the Project and MEG's plans to manage those effects.	[E] Volume 3, Section 1.1.2 MEG's Commitment to Air Quality Management
4.2.3 Monitoring	[A] Describe ambient air quality monitoring that will be conducted during each phase of the Project to assess air quality and the effectiveness of mitigation.	[A] Volume 3, Section 1.10 Monitoring
	[B] Describe monitoring programs MEG may implement to monitor the effects of acid deposition.	[B] Volume 3, Section 1.10 Monitoring
7.0 PUBLIC HEALTH AND SAFETY ASSESSMENT	(c) provide information, including chemical analysis and modeling results, on samples of selected environmental media (e.g. soil, water, air, vegetation, wild game, etc.) used in the assessment;	(c) Appendix 3-II Air Modelling Methods

1.2.3 Key Issues and Key Questions

Air quality related issues associated with the Project can be summarized in a series of Key Questions. The key questions that will be addressed as part of the Project Case in Section 1.8 are as follows:

AQPC-1: What effects could the Project and the existing and approved developments have on ambient air quality in the region?

AQPC-2: What effects could the Project and the existing and approved developments have on the deposition of acid-forming compounds in the region?

AQPC-3: What effects could the Project and the existing and approved developments have on concentrations of ground-level ozone in the region?

AQPC-4: Will emissions from the Project be in compliance with relevant provincial and federal emission guidelines?

AQPC-5: What effects could the Project and the existing and approved developments have on odours at the selected receptors?

AQPC-6: What is the contribution of the Project to greenhouse gas emissions?

The key questions that will be addressed as part of the Planned Development Case (PDC) in Section 1.9 are as follows:

> **AQPDC-1**: What effects could the Project, the existing and approved developments and the other regional developments have on ambient air quality in the region?
>
> **AQPDC-2**: What effects could the Project, the existing and approved developments and the other regional developments have on the deposition of acid-forming compounds in the region?

1.2.4 Temporal Considerations

The air quality assessment considers three specific levels of development in the region, rather than identifying specific years or time periods. This approach has been consistently applied to air quality assessments completed in the region and avoids the difficulties associated with determining emission profiles for all regional developments for specific years or time periods. Three assessment scenarios, were identified for evaluating possible air quality effects associated with the Project, namely:

- The Existing and Approved Case (EAC) includes an assessment of the cumulative air quality effects from the existing and approved industrial emission sources assuming full operation within the region, as well as estimated emissions from transportation and residential activities. Although the sources considered in the EAC have been approved, regional industrial sources are not operating at 100% of approved emission rates and an increase from existing levels of emissions to those used in the EAC will occur over several years. The EAC represents the cumulative load on the airshed that can occur without additional regulatory approvals.
- The Project Case provides a cumulative assessment of the emissions from the Project in combination with Existing and Approved emissions in the region. The Project Case represents the load on the airshed once the Project is in operation.
- The PDC includes a cumulative assessment of the existing and approved projects in the region, the Project and other publicly disclosed regional emission sources. Since the PDC includes planned projects, none of which have received approval to operate and some of which have yet to apply for approval, the emissions used in the PDC are based on the information available as of October 2007.

For each assessment scenario, it was assumed that all developments were operating at their maximum capacity at the same time. This assumption results in the maximum emission rates from regional sources.

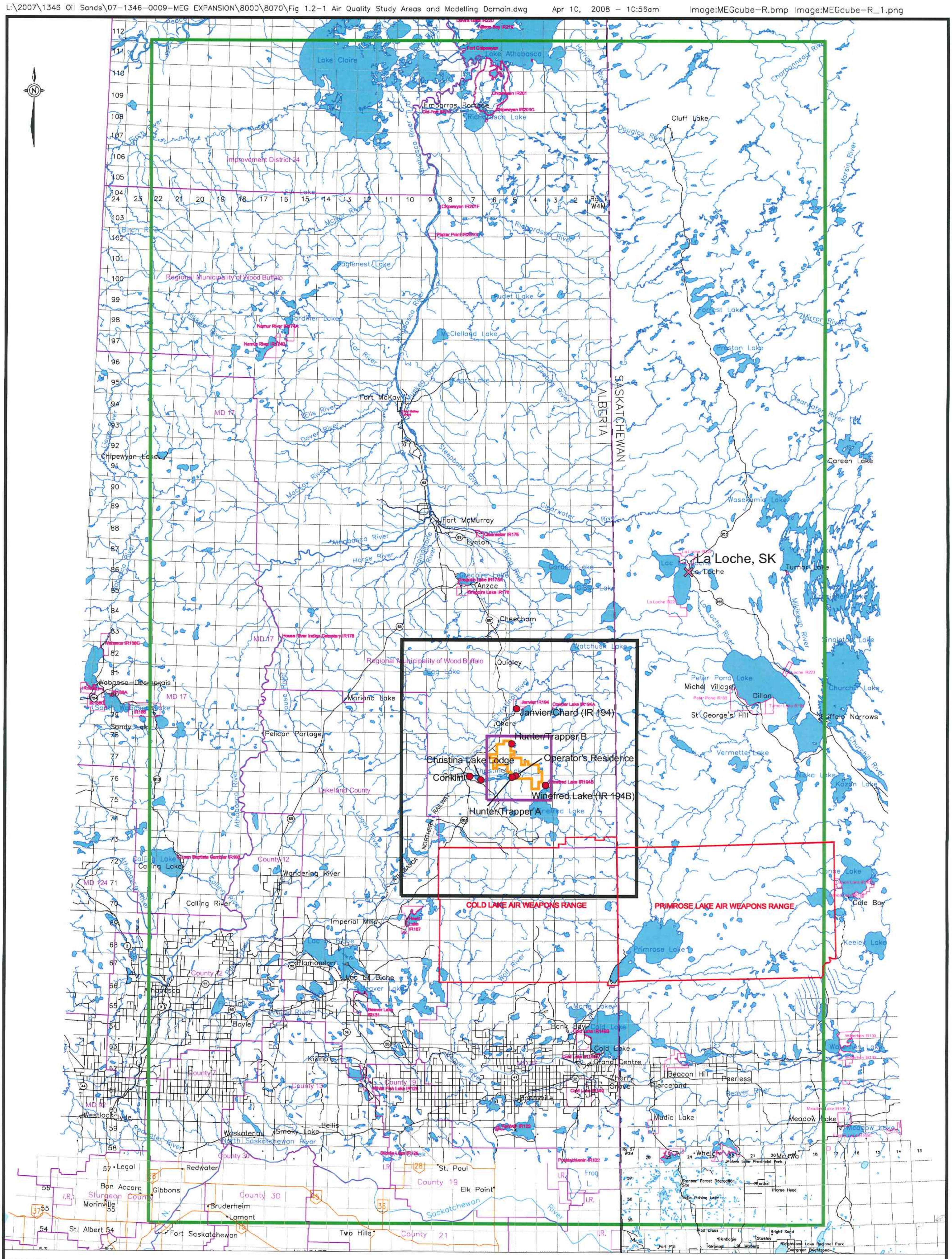
The current air quality in the region is discussed in Section 1.5 and a detailed summary of regional monitoring efforts is provided in Appendix 3-I.

1.2.5 Spatial Considerations

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

- The modelling domain defines the region within which emission sources were quantified and air quality predictions were performed. The modelling domain chosen for the air quality assessment is shown in Figure 1.2-1. It extends north of the Athabasca Oil Sands Region, south of Cold Lake, east into Saskatchewan and west to Ranges 22 and 23. It is large enough to encompass the effects related to air emissions from the oil sands developments in the region. The modelling domain includes key communities in Alberta and Saskatchewan.
- The Regional Study Area (RSA) defines the region over which modelling results are presented and is typically smaller than the modelling domain. The RSA was sized to meet the requirements of the Project TOR (AENV 2008). The air quality RSA for the Project is defined by a 110 by 120 km area, shown in Figure 1.2-1. This area is sufficiently large to ensure that the 0.17 keq/ha/yr PAI isopleth was within it, as per the Project TOR. The RSA is also large enough to capture the air quality effects associated with the Project. The RSA extends into the province of Saskatchewan to ensure that any potential air quality effects near the Alberta/Saskatchewan border are assessed.

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\8070\Fig 1.2-1 Air Quality Study Areas and Modelling Domain.dwg Apr 10, 2008 - 10:56am Image:MEGcube-R.bmp Image:MEGcube-R_1.png



30 0 30
SCALE KILOMETRES

LEGEND

—	ROAD
┼┼┼	RAILWAY
—	RIVER
▭	OPEN WATER
▭	INDIAN RESERVE
🟥	COLD LAKE AIR WEAPONS RANGE
●	SELECTED RECEPTOR
✕	SASKATCHEWAN RECEPTOR
▭	MEG LEASE BOUNDARY
▭	AIR LSA
▭	AIR RSA
🟩	AIR MODELLING DOMAIN

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

AIR QUALITY STUDY AREAS AND MODELLING DOMAIN

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000		FILE No.	Air Study Areas...
DESIGN	MS	28/11/07	SCALE AS SHOWN	REV. 0
CADD	PSR	01/04/08	FIGURE: 1.2-1	
CHECK	MS	01/04/08		
REVIEW	IGG	07/04/08		

- The Local Study Area (LSA) defines the area in the immediate vicinity of the Project where the majority of air quality effects are expected to occur. The LSA represents a subset of the RSA and allows a more focused assessment of the effects associated with the Project. The LSA was sized to meet the AENV Air Quality Model Guideline requirements for study areas (AENV 2003). The LSA (Figure 1.2-1) is defined by an area of approximately 30 by 30 km, encompassing the Project area.

One of the aims of the air quality evaluation is to put the potential effects into perspective for regional stakeholders. To facilitate this, maximum air quality concentrations were predicted for each of the receptors indicated in Table 1.2-2. This list includes one community and two locations in Alberta that are of importance to First Nations groups. These represent the primary population centres in or near the region that could potentially experience increased concentrations due to the Project. In addition, concentrations were predicted at two cabins, the Operator's Residence, the Christina Lake Lodge and along the Project maximum property boundary where persons could experience prolonged exposure to air emissions. For the purposes of this assessment, these eight receptors are referred to as the selected receptors. The relative locations of the selected receptors with respect to the Project are indicated in the table. The selected receptors located in the RSA are shown in Figure 1.2-2.

Table 1.2-2 Selected Receptors Included in the Air Quality Assessment

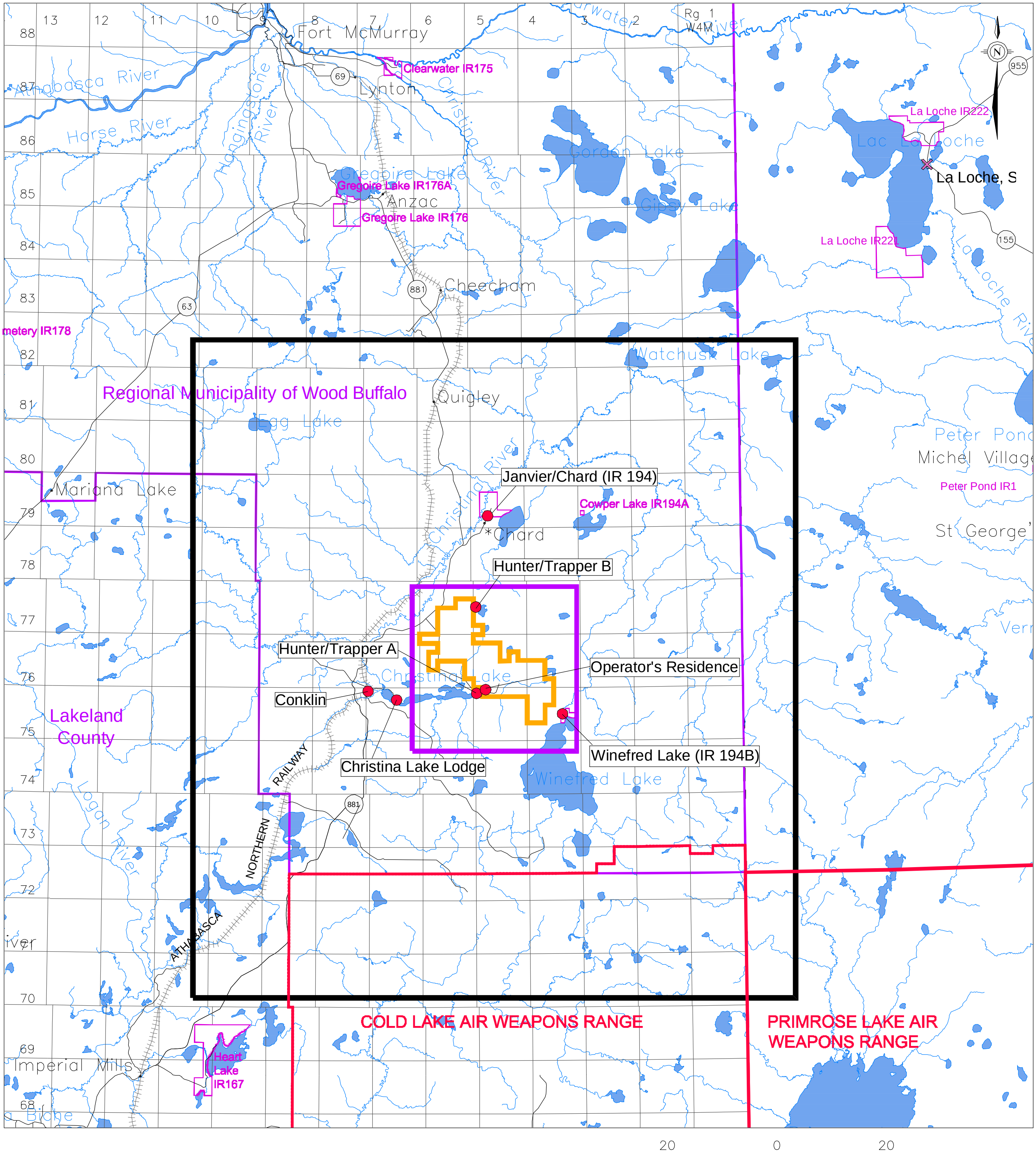
Receptors	Location[a]	
	Distance [km]	Direction
Conklin	24	W
Janvier/Chard (IR 194)	28	N
Winefred Lake (IR 194B)	15	SE
Hunter/Trapper A	6	SW
Hunter/Trapper B	12	NNW
Operator's Residence	4	SSW
Christina Lake Lodge	19	WSW
Maximum Property Boundary	n/a[b]	n/a[b]

(a) Distance and direction are relative to the Phase 2 Central Plant Site.

(b) Maximum Property Boundary Receptors are spaced 20 m apart around Plants 3A, 3B and the Central Plant.

n/a = Not applicable.

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\8070\Fig 1.2-2 location of Selected receptors-RSA.dwg Apr 10, 2008 - 11:11am



LEGEND

—	ROAD	🟧	MEG LEASE BOUNDARY
╫	RAILWAY	▭	AIR LOCAL STUDY AREA
—	RIVER	▭	AIR REGIONAL STUDY AREA
🟦	OPEN WATER		
▭	INDIAN RESERVE		
▭	COLD LAKE AIR WEAPONS RANGE		
●	SELECTED RECEPTOR		
×	SASKATCHEWAN RECEPTOR		

NOTE

* Also known as the Hamlet of Janvier

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 UTM ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

LOCATIONS OF SELECTED RECEPTORS IN THE REGIONAL STUDY AREA

MEG ENERGY CORP.

PROJECT 07.1346.0009.8000			FILE No. SelectReceptors-RSA	
DESIGN	MS	28/11/07	SCALE AS SHOWN	REV. 0
CADD	PSR	01/04/08	**FIGURE: 1.2-2**	
CHECK	MS	01/04/08		
REVIEW	IGG	07/04/08		

The effects of the Project were also evaluated in Saskatchewan due to its proximity. A receptor was placed at La Loche since it is one of the largest communities in Saskatchewan and is close to the Alberta-Saskatchewan border and to the Project. La Loche is located approximately 120 km NE of the Project.

1.3 CONSULTATION AND ASSESSMENT FOCUS

MEG has had ongoing consultations with its stakeholders in association with its growth plans and ongoing operations. This consultation has provided an opportunity for MEG stakeholders to identify issues of importance to them with respect to air quality. MEG stakeholders identified air quality issues which were considered in the EIA. The issues include the following:

- increases in ambient concentrations of air emissions within local communities as well as historic traditional land use areas;
- potential effects of acidic emissions as well as other air emissions on the health and productivity of area vegetation and wildlife;
- increases in the detection of odours related to industrial activity; and
- potential effects of air emissions on human health.

Details on MEG's consultation program and input received for the Project are provided in Volume 1, Section 5.

1.3.1 Air Quality Criteria

1.3.1.1 Ambient Objectives and Standards

Air emissions introduced into the atmosphere by industrial activities can have direct and indirect effects on humans, animals, vegetation, soil and water. For these reasons, environmental regulatory agencies have established ambient air concentration thresholds.

Table 1.3-1 presents the Alberta Ambient Air Quality Objectives (AAAQOs), the federal government Ambient Air Quality Objectives, the Canada-Wide Standards (CWS) and any other relevant objectives for criteria air pollutants. The compounds included in the table are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ground-level ozone (O_3) and particulate matter ($PM_{2.5}$). The listed objectives and standards refer to averaging periods ranging from one hour to one year.

Table 1.3-1 Federal, Alberta and Other Government Air Quality Criteria

Parameter	Alberta Ambient Air Quality Objectives	Canada-Wide Standards	Federal Air Quality Objectives			Other Relevant Criteria
			Desirable	Acceptable	Tolerable	
SO_2 [µg/m^3]						
1-Hour	450	—	450	900	—	—
24-Hour	150	—	150	300	800	—
Annual	30	—	30	60	—	—
NO_2 [µg/m^3]						
1-Hour	400	—	—	400	1,000	—
24-Hour	200	—	—	200	300	—
Annual	60	—	60	100	—	—
CO [µg/m^3]						
1-Hour	15,000	—	15,000	35,000	—	—
8-Hour	6,000	—	6,000	15,000	20,000	—
O_3 [µg/m^3]						
1-Hour	160	—	100	160	300	—
8-Hour	—	128	—	—	—	—
24-Hour	—	—	30	50	—	—
Annual	—	—	—	30	—	—
$PM_{2.5}$ [µg/m^3]						
1-Hour	80	—	—	—	—	—
24-Hour	30	30	—	—	—	25[a],65[b]
Annual	—	—	—	—	—	15[b]

[a] Newfoundland has a 24-hour standard of 25 µg/m^3 (Government of Newfoundland and Labrador 2004).

[b] U.S. EPA primary and secondary $PM_{2.5}$ standards are 65 µg/m^3 for 24 hours and 15 µg/m^3 annually (U.S. Government 2005, Website).

— = No criteria are available.

Sources: AENV 2007b; CCME 2000; Environment Canada 1981.

The federal government has established three levels of air quality objectives (Environment Canada 1981). The levels are described as follows:

- The maximum **Desirable** level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country and for the continuing development of control technology.
- The maximum **Acceptable** level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.
- The maximum **Tolerable** level denotes an air contaminant concentration that requires abatement (mitigation) without delay to avoid further deterioration to an air quality that endangers the prevailing Canadian lifestyle or ultimately, that poses a substantial risk to public health.

Canada-Wide Standards Process

The Canadian Council of Ministers of the Environment (CCME) reached an agreement in 1998 (CCME 1998, Website) on the harmonization of environmental regulations across Canada. As part of the process, the CCME has established a sub-agreement for the creation of the CWS with respect to the environment (including air quality).

The CWS are intended to be achievable standards that are based on sound science, and which take into consideration social implications and technical feasibility. Each provincial jurisdiction participating in the Harmonization Accord will implement the standards under existing provincial legislation, or by drafting new legislation.

The CWS process has been progressing for a limited set of compounds, namely ozone and fine particulate matter ($PM_{2.5}$). The first set of CWS for air pollutants was ratified by the CCME in June 2000. The compounds for which the CWS have been adopted include fine particulate matter ($PM_{2.5}$), ground-level ozone (O_3), benzene and mercury. The CCME has not yet established an acceptable ambient air quality criterion for benzene, but has set targets for reducing the emissions of benzene by approximately 40% from the 1995 levels by the end of 2010. Canada-Wide Standards for mercury emissions have only been developed from the base metal smelting sector and the waste incineration sector in Canada.

Trace Air Compounds

Industrial and residential activities in the modelling domain can result in the release of numerous trace air compounds. Although a thorough evaluation of the potential health effects associated with air emissions in the region has been provided in the Human Health Assessment (Section 3), the air quality assessment does provide a screening-level evaluation for the compounds that have air quality criteria.

The trace air compounds evaluated in the air quality assessment have been divided into four categories, namely:

- Total Reduced Sulphur (TRS) compounds;
- Volatile Organic Compounds (VOCs);
- Polycyclic Aromatic Hydrocarbons (PAHs); and
- airborne metals.

A summary of available criteria for relevant TRS compounds has been summarized in Table 1.3-2.

Table 1.3-2 Available Total Reduced Sulphur Criteria

Species	Alberta 1-Hour Objectives(a) [μg/m^3]	Alberta Annual Objectives(a) [μg/m^3]	TCEQ Effects Screening Levels(b) [μg/m^3]	
			Short-Term (1-Hour)	Long-Term (Annual)
total reduced sulphur	—	—	—	—
hydrogen sulphide (H_2S)	14	—	—	—
carbonyl sulphide (COS)	—	—	8	0.8
carbon disulphide (CS_2)	30	—	30	3
mercaptans	—	—	—	—
thiophenes	—	—	—	—

(a) Alberta Ambient Air Quality Objectives (AENV 2007b).

(b) The Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (ESLs) are used to evaluate the potential for effects to occur. They are not ambient air standards. If ambient levels exceed the ESLs, it does not necessarily indicate a problem (TCEQ 2003).

— = No criteria are available.

A summary of available criteria for relevant VOCs has been summarized in Table 1.3-3. The VOCs included in the table were identified through a screening-level health assessment.

Table 1.3-3 Available Volatile Organic Compound Criteria

Species	Alberta 1-Hour Objectives(a) [μg/m^3]	Alberta Annual Objectives(a) [μg/m^3]	TCEQ Effects Screening Levels(b) [μg/m^3]	
			Short-Term (1-Hour)	Long-Term (Annual)
total VOC	—	—	—	—
benzene	30	—	75	3
trimethylbenzene	—	—	1,250	125
C_2-C_8 aliphatic	—	—	—	—
C_9-C_{16} aliphatic	—	—	—	—
C_{16+} aliphatic	—	—	—	—
C_6-C_8 aromatic	—	—	—	—
C_9-C_{16} aromatic	—	—	—	—
hexane group(c)	—	—	1,760	176
aldehyde	—	—	—	—
ketone	—	—	—	—
acrolein	—	—	2.3	0.23
1,3-butadiene	—	—	110	11
formaldehyde	65	—	15	1.5
1,1,1-trichloroethane	—	—	10,800	1,080
OCDD (octachlorodibenzo-p-dioxin)	—	—	—	—
acetaldehyde	90	—	90	9
acetone	5,900	—	5,900	590
cumene	500	—	500	50
ethylbenzene	2,000	—	2,000	200
ethylene	1,200	30	1,200	120
2-ethylhexanol	600	—	—	—
toluene	1,880	—	1,880	188

Table 1.3-3 Available Volatile Organic Compound Criteria (continued)

Species	Alberta 1-Hour Objectives[a] [µg/m³]	Alberta Annual Objectives[a] [µg/m³]	TCEQ Effects Screening Levels[b] [µg/m³]	
			Short-Term (1-Hour)	Long-Term (Annual)
xylenes[d]	2,300	—	2,080	208
1,1,2-trichloroethanes	—	—	550	55
1.2-dichloropropane	—	—	1,150	115
1,3-dichloropropene	—	—	45	4.5
carbon tetrachloride	—	—	130	13
chlorobenzene	—	—	460	46
chloroethane	—	—	500	50
chloroform	—	—	100	10
dichloroethanes	—	—	—	—
methanol	2,600	—	2,620	262
methylene chloride	—	—	260	26
phenol	100	—	150	15
tetrachloroethanes	—	—	—	—
vinyl chloride	130	—	130	13
styrene	215	—	—	—
isopropanol	7,850	—	7,850	785
propylene oxide	480	30	70	7

(a) Alberta Ambient Air Quality Objectives (AENV 2007b).

(b) The Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (ESLs) are used to evaluate the potential for effects to occur. They are not ambient air standards. If ambient levels exceed the ESLs, it does not necessarily indicate a problem (TCEQ 2003).

(c) Screening levels are for n-hexane.

(d) Screening levels are for p-xylene.

— = No criteria are available.

Table 1.3-4 summarizes the available criteria for the PAHs considered in the air quality assessment. The PAHs included in the table were identified through a screening-level health assessment.

Table 1.3-4 Available Polycyclic Aromatic Hydrocarbon Criteria

Species	Alberta 1-Hour Objectives[a] [µg/m³]	Alberta Annual Objectives[a] [µg/m³]	TCEQ Effects Screening Levels[b] [µg/m³]	
			Short-Term (1-Hour)	Long-Term (Annual)
carcinogenic PAH group 1	—	—	—	—
carcinogenic PAH group 2	—	—	—	—
carcinogenic PAH group 3	—	—	—	—
pyrenes and substitutes[c]	—	—	0.5	0.05
fluorenes/fluoranthenes and substitutes[d]	—	—	10	1
acenaphthenes/acenaphthylenes[e]	—	—	1	0.1
anthracenes/phenanthrenes and substitutes[f]	—	—	0.5	0.05

Table 1.3-4 Available Polycyclic Aromatic Hydrocarbon Criteria (continued)

Species	Alberta 1-Hour Objectives(a) [µg/m^3]	Alberta Annual Objectives(a) [µg/m^3]	TCEQ Effects Screening Levels(b) [µg/m^3]	
			Short-Term (1-Hour)	Long-Term (Annual)
naphthalene and substitutes(g)	—	—	440	44
1-choloronaphthalene	—	—	—	—
2-choloronaphthalene	—	—	—	—
biphenyl	—	—	2.3	0.23

(a) Alberta Ambient Air Quality Objectives (AENV 2007b).

(b) The Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (ESLs) are used to evaluate the potential for effects to occur. They are not ambient air standards. If ambient levels exceed the ESLs, it does not necessarily indicate a problem (TCEQ 2003).

(c) Screening levels are for pyrene.

(d) Screening levels are for fluorene.

(e) Screening levels are for acenaphthene.

(f) Screening levels are for anthracene and phenanthrene.

(g) Screening levels are for naphthalene.

— = No criteria are available.

Table 1.3-5 summarizes the available criteria for the airborne metals considered in the air quality assessment. The metals included in the table were identified through a screening-level health assessment

Table 1.3-5 Available Airborne Metals Criteria

Species	Alberta 1-Hour Objectives(a) [µg/m^3]	Alberta Annual Objectives(a) [µg/m^3]	TCEQ Effects Screening Levels(b) [µg/m^3]	
			Short-Term (1-Hour)	Long-Term (Annual)
aluminum	—	—	50	5
antimony	—	—	5	0.5
arsenic	0.1	0.01	5	0.5
barium	—	—	5	0.5
beryllium	—	—	0.02	0.002
cadmium	—	—	0.1	0.01
chromium	1	—	1	0.1
cobalt	—	—	0.2	0.02
copper	—	—	10	1
lead	1.5	—	—	—
manganese	2	0.2	2	0.2
mercury	—	—	0.25	0.025
molybdenum	—	—	50	5
nickel	6	0.05	0.15	0.015
selenium	—	—	2	0.2
silver	—	—	0.1	0.01
strontium	—	—	20	2
tin	—	—	20	2
vanadium	—	—	—	—
zinc	—	—	—	—

(a) Alberta Ambient Air Quality Objectives (AENV 2007b).

(b) The Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (ESLs) are used to evaluate the potential for effects to occur. They are not ambient air standards. If ambient levels exceed the ESLs, it does not necessarily indicate a problem (TCEQ 2003).

— = No criteria are available.

1.3.1.2 Deposition Criteria

Deposition of sulphur and nitrogen compounds can result in long-term accumulations that have been associated with the acidification of soil and water. There are two management frameworks that have been established to manage acid deposition in Alberta and in the Oil Sands Region. This section discusses the management frameworks from the Clean Air Strategic Alliance (CASA) and CEMA.

Clean Air Strategic Alliance Framework

The CASA Target Loading Subgroup presented a provincial management strategy for acid deposition in the report entitled "Application of Critical, Target, and Monitoring Loads for the Evaluation and Management of Acid Deposition" (CASA 1999), which considers the sensitivity of the affected ecosystem in combination with the emissions.

The concepts of "critical loads", "target loads" and "monitoring loads" are the basis of the management strategy put forward by the CASA working group. These levels have been defined by CASA (1999) as follows:

- the critical load is defined as the highest load that will not cause long-term harmful effects on the most sensitive ecological systems;
- the target load is defined as the maximum level of atmospheric deposition that provides long-term protection from adverse ecological consequences, and is practically and politically achievable; and
- the monitoring load is the level of deposition predicted or estimated by a dispersion model that will trigger monitoring and/or research activities.

This approach specifies target loads of 0.25 keq/ha/yr for highly sensitive soils, 0.5 keq/ha/yr for moderately sensitive soils and 1.0 keq/ha/yr for soils with low sensitivity. For the purposes of the management strategy, these loads are to be determined over 1° latitude by 1° longitude grid cells.

A summary of the critical, target and monitoring loads for Alberta is provided in Table 1.3-6.

Table 1.3-6 Critical, Target and Monitoring Loads for Alberta

Sensitivity Level[(a)]	Critical Load[(b)] [keq/ha/yr]	Target Load[(b)] [keq/ha/yr]	Monitoring Load[(b)] [keq/ha/yr]
high sensitivity	0.25	0.22	0.17
moderate sensitivity	0.50	0.45	0.35
low sensitivity	1.00	0.90	0.70

(a) Sensitivity of ecosystem receptors (e.g., soils, waterbodies).

(b) Loads, in keq/ha/yr are determined over a grid cell 1º latitude by 1º longitude in size.

While the loads can be used as benchmarks to trigger further investigations, CASA (1999) noted that the target load was not to be used as an environmental objective.

Cumulative Environmental Management Association Framework

The NSMWG of CEMA presented an acid deposition management strategy for the Oil Sands Region in the report entitled "Recommendations for the Acid Deposition Management Framework for the Oil Sands Region in North-Eastern Alberta" in 2004 (CEMA 2004). This framework provides additional management tools that apply specifically to the Oil Sands Region. It is based on the concepts of emissions management, including the use of Best Available Demonstrated Technology (BADT), monitoring and predictive modelling, and ongoing monitoring and research. The framework is to be implemented in three stages:

- Stage 1 – the initial framework (targeted for 2003 to 2005);
- Stage 2 – the final framework (targeted for 2006); and
- Stage 3 – the first framework (revision targeted for 2009 to 2011).

The initial framework was released as part of the management framework document in 2004. The final framework has yet to be released.

The CEMA Acid Deposition Management Framework identifies two management units with specific objectives:

- within any four by four township floating block within the Oil Sands Region, an area exceeding a management objective of more than 100 km² would trigger action beyond the use of BADT; and
- within any 1º by 1º floating grid within the Oil Sands Region (that may be positioned anywhere along 10-second subdivisions of latitude/longitude lines), an area exceeding a management objective greater than the 95% level of protection outlined in the CASA provincial framework would constrain future emissions.

The NSMWG also recommends that the "time-to-effect" should be incorporated into how the management framework is applied; however, the methodology for incorporating it into the model predictions has not been finalized. The CEMA Acid Deposition Management Framework outlines three management response levels based on modelled results and the time within which the criteria might be exceeded, as follows:

- Green – no model predictions exceed the management objectives within 30 years of present and no monitoring results exceed management objectives;
- Yellow – model predictions exceed the management objectives within 15 to 30 years of present; and
- Red – model predictions exceed the management objectives within 15 years of present and monitoring results confirm management objectives are being exceeded.

1.3.1.3 Air Emissions Criteria

In addition to ambient air quality objectives and standards, numerous regulatory agencies have developed criteria designed to place limits on acceptable emissions. This section discusses some of the emission criteria that may be applicable to the Project.

Emissions From Commercial/Industrial Boilers and Heaters

The CCME has published National Emission Guidelines for Commercial/ Industrial Boiler and Heater Sources (CCME 1998). The values set out in this document are not regulations; however, they are often referenced by regulatory agencies as targets that should be achieved for approval and permit compliance. A summary of these guidelines is presented in Table 1.3-7.

Table 1.3-7 Emission Guidelines for Industrial Boilers and Heaters

Parameter	Fuel Type	CCME Emission Limits [g/GJ][a]	
		10.5 to 105 GJ/hr[b]	>105 GJ/hr[b]
NO_X	gaseous fuel	26	40
	distillate oil	40	50
	residual oil (<0.35% N)[c]	90	90
	residual oil (>0.35% N)	110	125
CO	all fuels	125	125

[a] The CCME emission limits are given in units of grams per gigajoule of energy input [g/GJ].

[b] Boiler capacities are based on the power input in units of gigajoules per hour [GJ/hr].

[c] N = Nitrogen.

Sulphur Recovery

The ERCB has set out guidelines for sulphur recovery in Interim Directive (ID) 2001-3 (EUB 2001). These guidelines, which are based on the earlier Information Letter (IL) 88-33 (EUB 1998), have been explicitly extended to include the recovery of sulphur from sour gas processing plants, new emissions from other types of upstream petroleum operation and acid gas streams produced at downstream petroleum facilities. Table 1.3-8 includes a general outline of the sulphur recovery requirements in ID 2001-3.

Table 1.3-8 Sulphur Recovery Guidelines (Alberta)

Inlet Sulphur Rate [t/d]	% of Inlet Sulphur Recovery	
	Design Sulphur Recover Criteria	Calendar 90-day Sulphur Recovery Criteria
1 to 5	70	69.7
>5 to 10	90	89.7
>10 to 50	96.2	95.9
>50 to 2,000	98.5 to 98.8[a]	98.2 to 98.5[b]
>2,000	99.8	99.5

[a] Recovery = 98.18185 + 1.87259 x log (sulphur inlet rate).

[b] Recovery = 97.88185 + 1.87259 x log (sulphur inlet rate).

Fugitive Volatile Organic Compound Emissions

The CCME has prepared an Environmental Code of Practice for the Measurement and Control of Fugitive VOC Emissions from Equipment (CCME 1993) as a part of a NO_X/VOC Management Plan. This document includes environmental considerations for the measurement and control of VOC emissions from equipment leaks in operating plants. Practices are also included for the application, performance, testing for compliance, record-keeping and measurement of these emissions. Such practices are intended to reduce the contribution of fugitive VOC emissions from equipment leaks, and are expected to be followed by operators of facilities like the Project.

Recovery of Flared Gases

Directive 060 (Upstream Petroleum Industry Flaring, Incinerating and Venting) provides regulatory requirements and guidelines for flaring, incinerating and venting in Alberta (EUB 2006). Some of the initiatives addressed in Directive 060 include requirements for improved flare efficiencies, evaluation of alternatives to routine flaring and tighter reporting requirements. The new requirements in Directive 060 were effective January 31, 2007.

1.3.2 Air Assessment Approach

The air quality assessment involves dispersion modelling to predict ground-level concentrations. While numerous models are available for use, not all of them are appropriate for evaluating the Project emissions. The air dispersion model selection was based on numerous criteria, including:

- the capability of the model to evaluate the various regional source types (e.g., point, area, volume sources);
- the ability of the model to predict the necessary pollutant concentrations;
- the technical basis of the model which must be scientifically sound and must incorporate the most current understanding of the dispersion of airborne contaminants;
- the assumptions and algorithms used in the model which must be clearly set out and have undergone rigorous independent scrutiny by peers in the technical community;
- the predictions made by the model which should be consistent with local observations; and
- the model is recognized in the AENV air quality modelling guidelines (AENV 2003) as one suitable for use.

A discussion of model selection and evaluation is provided in Appendix 3-II.

1.3.2.1 CALPUFF Dispersion Model

The evaluation of air quality effects associated with the Project depends on the use of dispersion models to predict concentrations for the EAC, Project Case and PDC. In this air quality assessment, ambient concentrations were predicted using the CALPUFF model run in the dynamic (3-D) mode. This model has been identified as appropriate for modelling in the region by AENV.

1.3.2.2 Computer Aided Learning in Meteorology (CALMET) Wind Fields

The 3-D wind fields used in the CALPUFF dispersion modelling completed for the Project EIA were created using the CALMET model preprocessor (CALMET) developed specifically for use with the CALPUFF model. The CALMET modelling was completed over an area of 390 by 605 km and for a period of 12 months (January through December 2002). Due to the size of the meteorological domain used for evaluating the air quality effects associated with the Project, it was necessary to use data from continental meteorological models as well as surface stations. The winds over western Canada have been simulated for 2002 using the Fifth-generation National Center of Atmospheric Research (NCAR) Penn State Mesoscale Model (MM5). A description of the CALMET 3-D wind fields used in the air quality assessment has been provided in Appendix 3-II.

1.3.2.3 Air Modelling Methods

The dispersion modelling completed for the air quality assessment was consistent with AENV Air Quality Model Guidelines (AENV 2003). Key aspects of the dispersion modelling approach are discussed in Appendix 3-II and include:

- selection of dispersion modelling receptors consistent with AENV guidance;
- development of a regional air emissions inventory incorporating major regional sources;
- selection of dispersion model input parameters recommended for use in Alberta and consistent with AENV guidance;
- conversion of predicted NO_X concentrations to NO_2 concentrations using an ambient relationship accepted by AENV; and
- inclusion of regional background PAI values developed by AENV.

1.3.2.4 Model Limitations

The evaluation of changes in air quality depends primarily on the use of air dispersion models to predict the ambient levels expected in the future. Dispersion models employ assumptions that simplify the random processes associated with atmospheric motions and turbulence. This simplification of the processes limits the capability of a model to replicate individual events. The predictive strength of the model lies in the capability to predict an average for a given set of meteorological conditions. Other factors that limit the capability of a model to predict values that match observations are limitations in the input data and information used by the modeller. A detailed review of the dispersion model used in the air quality assessment is provided in Appendix 3-II.

The use of proper input parameters in the CALPUFF model reduces the level of uncertainty of predictions. The primary inputs for the CALPUFF model are meteorological data, which is specific to the region, and emission source parameters and emission rates. A detailed model evaluation was performed and is documented in Appendix 3-II. The results indicate that the model used for this assessment satisfactorily predicts air quality concentrations in the Oil Sands Region. Although a similar validation exercise was not completed in the vicinity of the Project due to a lack of monitoring data, the same methods as are used for the Oil Sands Region were used to develop meteorological, emission and model input data for this assessment. Therefore, it is expected that the modelling analyses for this assessment will provide the same level of performance as shown in the model validation. Appendix 3-II provides additional details regarding how scientific uncertainty was addressed in this assessment.

1.3.2.5 Impact Classification

Emissions from the Project could affect air quality and acid deposition that could, in turn, affect the receiving environment. The impact classifications of the potential effects of changes in air quality on the receiving environment are dealt with in the Environmental Health Assessment (Section 3) and the Air Emission Effects on Ecological Receptors (Section 4).

1.4 MITIGATION

The Project has incorporated compliance with the relevant provincial and federal emissions guidelines in the design of the process and selection of equipment as outlined in Section 1.1.2.1.

1.5 BASELINE SUMMARY

1.5.1 INTRODUCTION

This section provides an overview of the existing air quality in the Oil Sands Region in the vicinity of the Project. A more detailed description of the existing air quality and climate is provided in Appendix 3-I.

1.5.2 EXISTING AIR QUALITY

Several ambient air quality monitoring programs are currently operating in the Oil Sands Region. These programs are comprised of continuous monitoring, passive monitoring and intermittent mobile air monitoring. The programs are administered by AENV and two regional airshed associations, namely WBEA and LICA. The principal compounds that are monitored by the various programs include SO_2, NO_2, H_2S, O_3, Total Hydrocarbons (THC), TRS and $PM_{2.5}$.

Continuous ambient air quality monitoring is conducted throughout the region by WBEA and LICA. These are multi-stakeholder, non-profit organizations whose purpose is to provide objective third-party monitoring and analysis of regional air quality. Both WBEA and LICA also conduct passive monitoring, which allows for the direct measurement of long-term ambient concentrations of selected compounds, which include SO_2, NO_2, H_2S and O_3. To complement the continuous and passive monitoring, AENV conducts intermittent mobile air monitoring surveys to provide a “snapshot” of the air quality at locations not regularly monitored as part of the regional networks. These surveys are typically conducted at several locations over a number of days.

The Project is situated at the southern boundary of the Regional Municipality of Wood Buffalo (RMWB) and is therefore covered by the WBEA network. However, data from LICA has also been reviewed and included, as it may provide a better representation of ambient air quality in the vicinity of the Project. This is because in the LICA airshed, the monitoring is primarily focused around in-situ oil sands developments as opposed to the large oil sands mining developments principally monitored by WBEA. Therefore, the ambient air quality data from the nearest and most representative WBEA and LICA stations have been summarized to describe the baseline conditions in the Project area.

The nearest continuous monitoring station that has valid data and is a better representation of the air quality in the vicinity of the Project is the LICA Cold Lake South station (although the station is located in an area that is more developed than the Project site). Continuous monitoring data were taken from the LICA Cold Lake South station for the monitoring period from November 2005 through December 2006. Passive monitoring data were taken from the WBEA 210 site from July to December 2005 (Appendix 3-I, Figure 1).

Additionally, the latest mobile monitoring data from two surveys completed in the region have been included. The first mobile survey was conducted for twenty days in 2001 and 2002 at sixteen sites in the Cold Lake, Bonnyville and Elk Point areas (AENV 2002). The second survey was conducted in the Lakeland area over eighteen days in 2003 and 2004 at twelve sites (AENV 2005). A detailed summary of the rationale for selecting stations and monitoring data is presented in Appendix 3-I.

1.5.2.1 Sulphur Dioxide

The maximum 1-hour, 24-hour and annual SO_2 concentrations measured at the Cold Lake South station are below the respective Alberta Ambient Air Quality Objectives (AAAQOs). All of the monitored concentrations are less than 20% of the respective AAAQOs. The passive and mobile monitored SO_2 concentrations are similar in magnitude to those monitored continuously at the Cold Lake South station.

1.5.2.2 Nitrogen Dioxide

The maximum 1-hour, 24-hour and annual NO_2 concentrations measured at the Cold Lake South station are below the respective AAAQOs. All of the monitored concentrations are less than 25% of the respective AAAQOs. The passive and mobile monitored NO_2 concentrations are also similar in magnitude to those monitored continuously at the Cold Lake South station.

1.5.2.3 Hydrogen Sulphide

Continuous and passive monitoring of H_2S is not currently being conducted at the monitoring sites nearest to the Project. However, AENV has conducted two mobile monitoring surveys in the region, which included H_2S monitoring. During the Cold Lake, Bonnyville and Elk Point AENV mobile air monitoring survey, two exceedances of the 1-hour AAAQO were measured. These exceedances were measured at locations near the Canadian Natural Resources Limited (Canadian Natural) Wolf Lake facility. During the Lakeland mobile air monitoring survey, the maximum 1-hour H_2S concentration was well below the AAAQO and the median H_2S concentrations were all below the detection limit of the instrument used.

1.5.2.4 Ozone Concentrations

The maximum 1-hour O_3 concentration measured at the Cold Lake South station is below the 1-hour AAAQO. Similarly, the maximum 8-hour O_3 concentration is below the CWS. The passive and mobile monitored concentrations are similar in magnitude to those monitored continuously at the Cold Lake South station.

1.5.2.5 Total Hydrocarbon Concentrations

The maximum 1-hour, 24-hour and annual THC concentrations measured at the Cold Lake South station are all below 5 mg/m^3. These concentrations are similar in magnitude to those monitored in the AENV mobile surveys.

1.5.2.6 Total Reduced Sulphur Concentrations

The maximum 1-hour, 24-hour and annual TRS concentrations measured at the Cold Lake South station are all below 15 $\mu g/m^3$. In addition to the continuous monitoring data, TRS data were also collected by the AENV mobile surveys. During the Cold Lake, Bonnyville and Elk Point mobile air monitoring survey, the maximum TRS concentration measured in the region was 78 $\mu g/m^3$, which was near the Canadian Natural Wolf Lake facility. The median TRS concentration was 1.4 $\mu g/m^3$ (AENV 2002). During the Lakeland mobile air monitoring survey, the maximum 1-hour TRS concentration measured in the region was 4.2 µg/m³ near the Petrovera Frog Lake facility. The median TRS concentration was less than the detection limit of the instruments (AENV 2005).

1.5.2.7 Fine Particulate Matter

The maximum 1-hour $PM_{2.5}$ concentration monitored at the Cold Lake South station exceeds the AAAQO of 80 µg/m³ on one occasion. The maximum 24-hour $PM_{2.5}$ concentration monitored at the Cold Lake South station is below the AAAQO of 30 µg/m³, and the 98th percentile 24-hour $PM_{2.5}$ concentration is below the CWS of 30 µg/m³. The mobile monitored $PM_{2.5}$ concentrations are similar in magnitude to those monitored continuously at the Cold Lake South station.

1.6 EXISTING AND APPROVED CASE

1.6.1 Introduction

The EAC assessment considers the air quality in the region resulting from existing and approved industrial and community emission sources. The EAC does not include the Project.

1.6.2 Emissions

Oil sands activities in the region have the potential to affect regional air quality. Table 1.6-1 summarizes the existing and approved oil sands developments that were included in the modelling domain of the EAC. As previously discussed in Section 1.2.5, the modelling domain defines the region within which emission sources were quantified and air dispersion modelling was conducted.

Table 1.6-1 Oil Sands Activities Included in the Existing and Approved Case

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
MEG Energy Corp.			
Christina Lake Regional Project – Pilot	existing/approved	—	—
Christina Lake Regional Project – Commercial (Phases 2 and 2B)	approved	—	—
EnCana FCLL Oil Sands Ltd.			
Christina Lake Thermal Project	existing/approved	14.49	SW
Foster Creek Pilot	existing/approved	67.03	S
Foster Creek Phases 1 and 2	existing/approved	67.59	S
Devon Canada Corporation			
Jackfish SAGD Project	approved	18.07	SSW
Petrobank			
Whitesands Pilot Project	existing/approved	33.63	W
ConocoPhillips Canada Resource Ltd.			
Surmont Commercial SAGD Project	approved	60.31	NNW
Petro-Canada			
Meadow Creek In-Situ Project	approved	81.58	NNW
MacKay River In-Situ Project	approved	169.44	NNW
Dover SAGD Pilot and VAPEX Pilot	existing/approved	171.93	NNW
OPTI Canada Inc./Nexen Canada Ltd.			
Long Lake Pilot Project	existing/approved	83.29	N
Long Lake Commercial Project	approved	83.86	N
Connacher Oil and Gas Limited			
Great Divide Oil Sands Project	approved	85.41	NW
Canadian Natural Resources Limited			
Primrose North	approved	88.21	S
Burnt Lake Project	existing/approved	98.82	SSE
Primrose South	existing/approved	99.76	S
Primrose East In-Situ Oil Sands Project	approved	99.93	SSE
Wolf Lake	existing/approved	107.92	S
Horizon Oil Sands Project	approved	196.55	NNW
Japan Canada Oil Sands Limited			
Hangingstone In-Situ Pilot Project	existing/approved	92.97	NW
Imperial Oil Resources Limited			
Cold Lake In-Situ Project	existing/approved	115.34	S
Imperial Oil Resources Ventures Limited			
Kearl Oil Sands Project	approved	194.28	N
Husky Energy Inc.			
Tucker Thermal Project	existing/approved	122.77	S
Sunrise Thermal Project	approved	176.63	N
Shell Canada Limited			
Orion EOR Project	approved	127.20	S
Jackpine Mine – Phase 1	approved	180.19	NNW
Suncor Energy Inc.			
South Tailings Pond	existing/approved	139.57	NNW
Lease 86/17, Steepbank & Millennium Mines	existing/approved	148.98	NNW
Voyageur Upgrader	approved	153.08	NNW
Upgrader Complex	existing/approved	156.44	NNW
North Steepbank Extension Mine	approved	156.46	NNW

Table 1.6-1 Oil Sands Activities Included in the Existing and Approved Case (continued)

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
Millennium Coker Unit (MCU)	approved	156.61	NNW
Millennium Vacuum Unit (MVU)	existing/approved	156.93	NNW
Firebag Enhanced Thermal Solvent (ETS) Pilot Project	existing/approved	172.60	N
Firebag SAGD Project	existing/approved	174.92	N
Syncrude Canada Ltd.			
Mildred Lake Mining and Upgrading, Upgrader Expansion and Emissions Reduction Program (ERP)	existing/approved	162.79	NNW
Aurora South Mine	approved	176.24	NNW
Aurora North Mine	existing/approved	188.12	NNW
Birch Mountain Resources Ltd.			
Muskeg Valley Quarry	existing/approved	176.89	NNW
Albian Sands Energy Inc.			
Muskeg River Mine and Muskeg River Mine Expansion	existing/approved	183.73	NNW
Total Joslyn Ltd. E&P			
Joslyn Creek SAGD Project – Phase 1 and Commercial	existing/approved	193.19	NNW
Petro-Canada Oil Sands Inc.			
Fort Hills Oil Sands Project	approved	199.03	NNW

(a) Distance and direction are relative to the Central Plant.

Table 1.6-2 summarizes the EAC emission rates assumed for the industrial and non-industrial sources included in the modelling domain. A detailed summary of the emissions from EAC sources is presented in Appendix 3-II.

The emissions presented below include both stream-day and calendar-day SO_2 emissions. The SO_2 emission rates during normal operations are often referred to as “stream-day” rates, when all pollution control and facility processes are on-stream and in operation. The average annual SO_2 release rates are often referred to as “calendar-day” emission rates and are determined by dividing the annual SO_2 emission rate from the facility by 365 days. A discussion of stream-day and calendar-day SO_2 emission rates is presented in Appendix 3-II.

Table 1.6-2 Summary of the Existing and Approved Case Emissions

Source	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
MEG Energy Corp. Christina Lake Regional Project Pilot	0.00	0.00	0.21	0.19	0.02	0.01	0.00
MEG Energy Corp. Christina Lake Regional Project Phase 2	0.01	0.01	2.76	1.72	0.15	0.08	0.01
MEG Energy Corp. Christina Lake Regional Project Phase 2B	1.52	1.52	3.52	2.41	0.21	0.12	0.01
other industry south of Fort McMurray[b]	60.39	65.24	102.33	107.87	6.37	6.32[c]	0.25[c]
other industry north of Fort McMurray[b]	136.83	204.35	383.23	314.41	24.85	667.22[c]	7.38[c]
communities	0.19	0.19	0.92	—[d]	—[d]	2.13	0.00
Total[e]	**198.93**	**271.30**	**492.95**	**426.59**	**31.59**	**675.87**	**7.64**

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

[b] Includes the emissions from other oil sands developments and industrial sources in the modelling domain.

[c] Volatile Organic Compounds (VOCs) and Total Reduced Sulphur (TRS) emissions include variable pond emission rates from the Suncor, Canadian Natural and Imperial Oil developments as discussed in Appendix 3-II. Emissions presented above include the maximum daily emission rate from these developments.

[d] Background data were added to model predictions to represent CO and $PM_{2.5}$ emissions from the communities. Therefore, community emissions of CO and $PM_{2.5}$ were not modelled. A description of the background data used is provided in Appendix 3-II.

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

1.6.3 Air Quality Predictions

The EAC air quality assessment is a cumulative evaluation of atmospheric releases from all of the existing and approved activities in the region, including oil sands operations, other industrial operations and community activities. The air quality concentration and deposition predictions were made using the CALPUFF dispersion model.

The EAC includes a total of 271.30 t/cd (198.93 t/sd) of SO_2 emissions and 492.95 t/d of emissions of NO_X. Although the EAC sources have been approved, it may take several years before the activities in the region increase emissions from the current level to the levels assessed. The Existing and Approved Case ambient air predictions are presented in detail in Appendix 3-III.

The peak concentrations represent the highest 1-hour, 24-hour and annual predictions from the CALPUFF model. The maximum 1-hour values exclude the eight highest 1-hour predictions, as recommended by AENV (AENV 2003) for determining compliance with the AAAQOs. The peak predictions are presented for most compounds, with the exception of SO_2 and NO_2. The 1-hour maximum predictions are presented for SO_2 and NO_2 in the region and at the selected receptors.

The maximum EAC predictions of 1-hour, 24-hour and annual ground-level SO_2 concentrations in the RSA (outside of developed areas) were predicted to be 283.1, 66.0 and 7.4 µg/m³, respectively. Within the LSA (outside of developed areas), the maximum 1-hour, 24-hour and annual SO_2 concentrations were predicted to be 283.1, 66.0 and 7.4 µg/m³, respectively. In both the LSA and RSA, the 1-hour, 24-hour and annual predictions were below the respective AAAQO levels of 450, 150 and 30 µg/m³.

The maximum 1-hour, 24-hour and annual NO_2 predictions within the RSA (outside of developed areas) were 158.1, 65.6 and 5.5 µg/m³, respectively. Within the LSA (outside of developed areas), the maximum 1-hour, 24-hour and annual NO_2 concentrations were predicted to be 87.9, 41.8 and 3.8 µg/m³, respectively. The maximum 1-hour, 24-hour and annual NO_2 levels predicted in the RSA and LSA (outside of developed areas) were below the AAAQO levels of 400, 200 and 60 µg/m³.

The EAC predictions of the Potential Acid Input (PAI) indicate that areas above 0.17 and 0.25 keq/ha/yr thresholds are possible within both the RSA and the LSA. The Clean Air Strategic Alliance have adopted a series of critical, target and monitoring loads to help manage acid deposition in Alberta on the basis of 1° by 1° grid cells (CASA 1999). There are 25 such grid cells overlaying the air quality modelling domain (Appendix 3-II, Section 2.3.8), all classified as being sensitive to acid deposition. The EAC PAI levels were above 0.25 keq/ha/yr in two grid cells north of Fort McMurray where the majority of approved oils sands operations are located. These two cells are located about 150 km NNW of the Project. None of the remaining 23 grid cells had PAI levels above the 0.17 keq/ha/yr monitoring load. The grid cell that the Project is located within is centred on 56º×111º and had a predicted PAI level of 0.161 keq/ha/yr.

All EAC predictions of SO_2, NO_2, CO, H_2S, Carbonyl Sulphide (COS), Carbon Disulphide (CS_2), benzene, VOCs compounds, $PM_{2.5}$, PAH compounds and trace metals at the selected receptors were below the respective AAAQO levels or other criteria, as applicable. The evaluation of possible effects of these compounds has been presented in the Environmental Health Assessment (Section 3) and Air Emission Effects on Ecological Receptors (Section 4).

In addition, all EAC predictions of SO_2, NO_2, CO, H_2S, Carbonyl Sulphide (COS), Carbon Disulphide (CS_2), benzene, VOCs compounds, $PM_{2.5}$, PAH compounds and trace metals at La Loche, Saskatchewan were below the respective AAAQO levels or other criteria, as applicable.

1.7 LINKAGE ANALYSIS

The potential for the Project to affect air quality is first considered using a linkage analysis. This analysis describes how Project activities could potentially lead to environmental change (Human Health: Section 3; Air Emissions Effects: Section 4; Wildlife Health:, Appendix 3-VI; Soils: Volume 5, Appendix 5-I; Terrestrial Vegetation: Volume 5, Appendix 5-II). Figures 1.7-1 to 1.7-3 depict linkages identified for the key questions for the Air Quality Assessment.

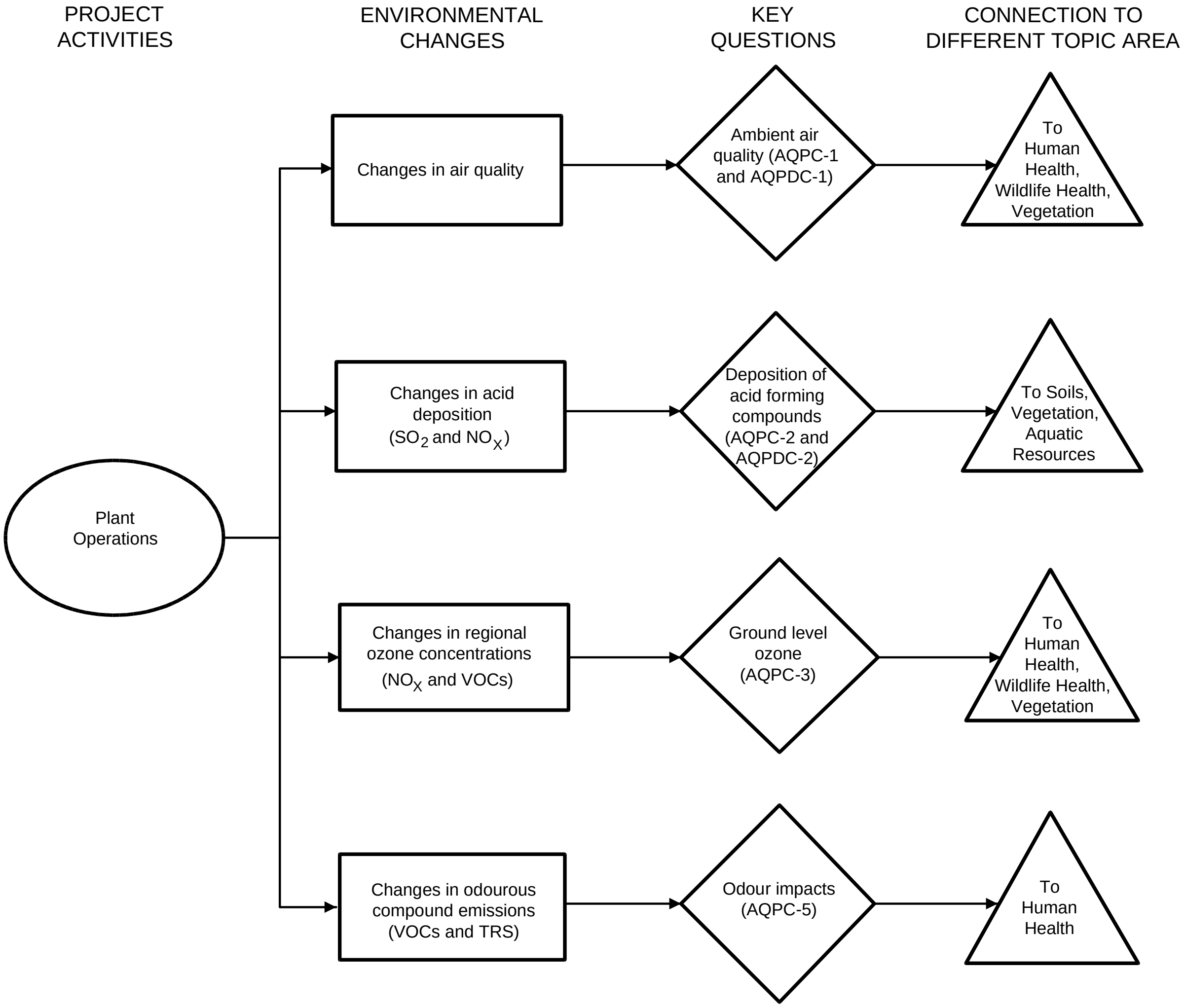
1.7.1 Project Case - Regional Air Quality

The potential for emissions from the Project to affect regional air quality is a key issue. Figure 1.7-1 depicts the linkage pathway for this Key Question. Emissions from the Project will change regional emissions and potentially ambient air quality, which in turn, may affect other disciplines presented in Figure 1.7-1.

1.7.2 Project Case – Regional Acid Deposition

The deposition of sulphur and nitrogen compounds can result in long-term accumulations that have been associated with the acidification of terrestrial and aquatic ecosystems. For this reason, the effects of potential emissions of oxides of nitrogen (NOX) and sulphur dioxide (SO2) from the Project on acid deposition in the region have been examined. Potential Acid Input was used to estimate acidification which takes into account the effect of sulphur and nitrogen species as well as the neutralizing effect of available base cations. The evaluation of acid-forming compounds from the Project was accomplished by predicting the regional PAI using the CALPUFF dispersion model.

Figure 1.7-1 depicts the linkage pathway for this key question. The figure indicates that emissions from the Project will change regional emissions and potentially ambient air quality, which in turn, may affect other disciplines presented in Figure 1.7-1 Consequently, an impact analysis was conducted. The evaluation of impacts that could result from acid-forming emissions is undertaken in the Air Emission Effects on Ecological Receptors section (Section 4).



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

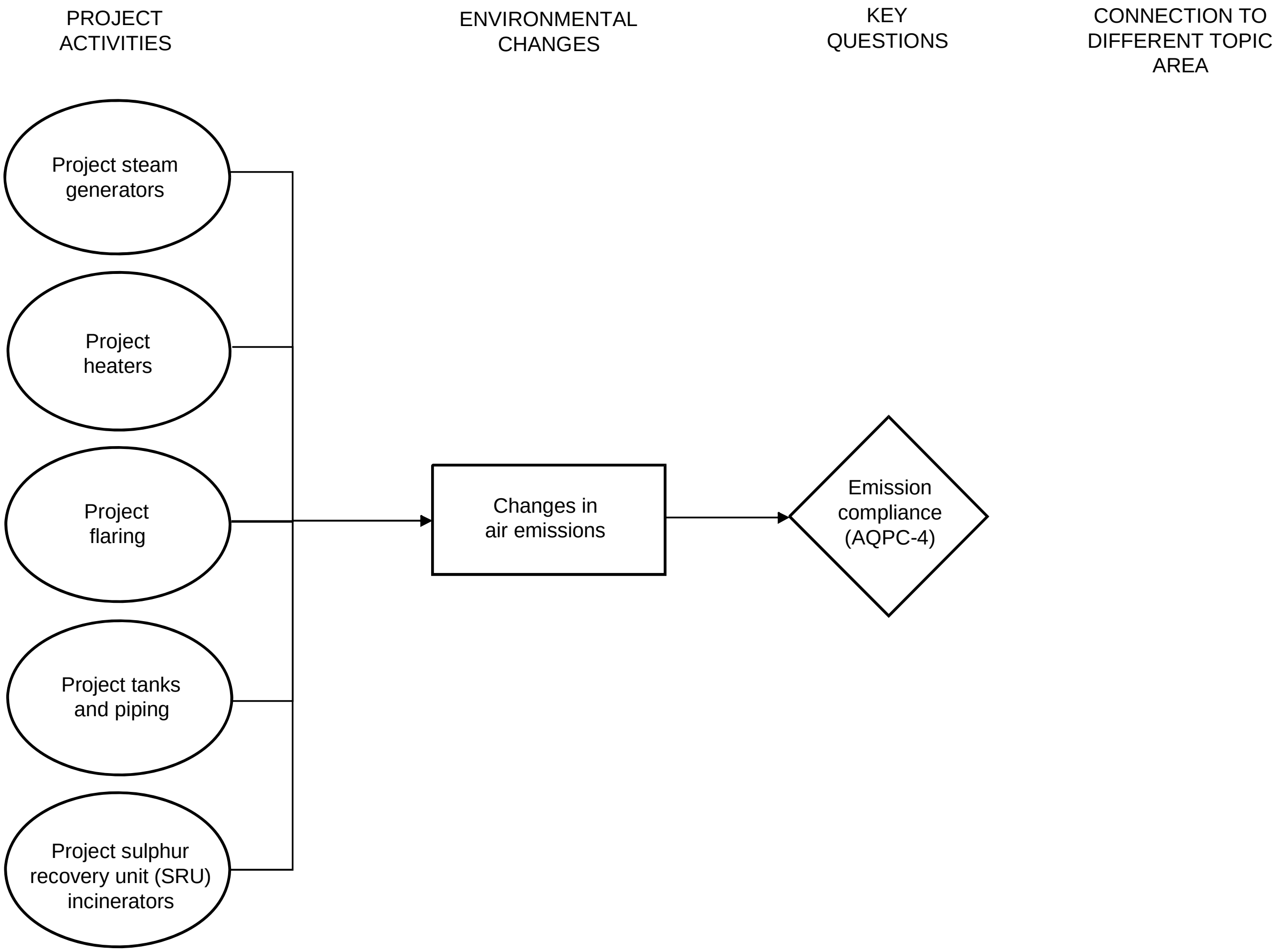
AIR LINKAGE DIAGRAM
FOR KEY QUESTIONS

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000		FILE No.	Air Linkage Diagram
DESIGN	MS	29/01/08	SCALE AS SHOWN	REV. 0
CADD	TRE	01/04/08		
CHECK	MS	01/04/08		
REVIEW	IGG	07/04/08		

FIGURE: 1.7-1

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\8020\Fig 1.7-1 Air Linkage Diagram for Key Questions.dwg Apr 10, 2008 - 11:18am



PROJECT
CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

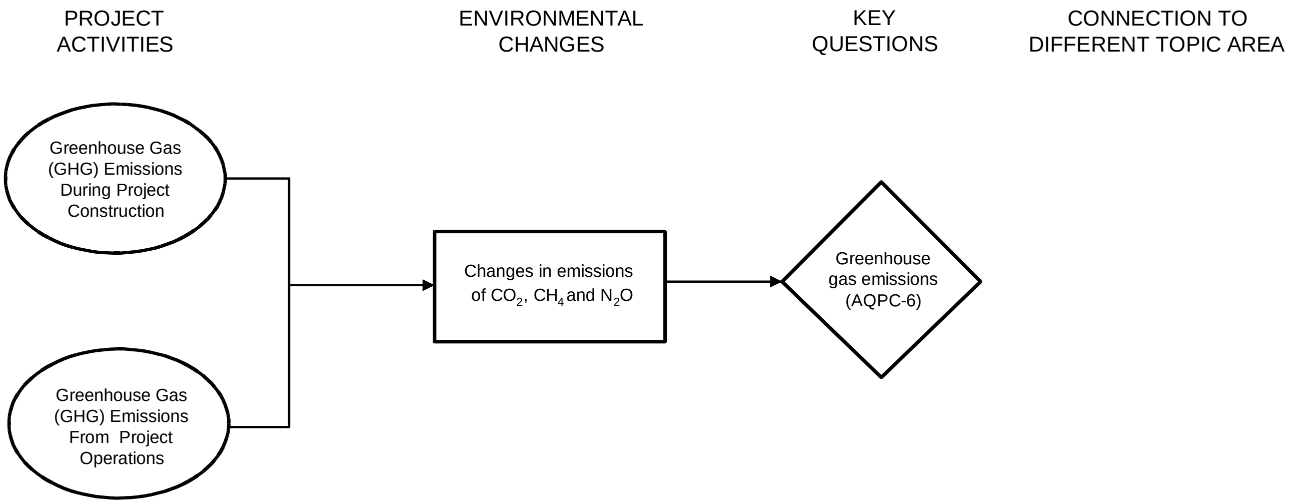
TITLE
AIR LINKAGE DIAGRAM FOR KEY QUESTION AQPC-4

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000		FILE No. Air Linkage Diagram
DESIGN	MS	29/01/08	SCALE AS SHOWN REV. 0
CADD	TRE	29/01/08	
CHECK	MS	29/01/08	
REVIEW	IGG	07/04/08	

FIGURE: 1.7-2

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\8020\Fig 1.7-2 Air Linkage Diagram for Key Question AQPC-4.dwg Apr 10, 2008 - 11:21am



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

AIR LINKAGE DIAGRAM FOR KEY QUESTION AQPC-6

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000		FILE No. Air Linkage Diagram	
DESIGN	MS	29/01/08	SCALE AS SHOWN	REV. 0
CADD	TRE	01/02/08	**FIGURE: 1.7-3**	
CHECK	MS	01/02/08		
REVIEW	IGG	07/04/08		

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\8020\Fig 1.7-3 Air Linkage Diagram for Key Question AQPC-6.dwg Apr 17, 2008 - 2:47pm

1.7.3 Project Case - Ground-Level Ozone

The potential for emissions from the Project to affect ground-level ozone concentrations in the region is considered in Key Question AQPC-3.

Although the Project does not produce any direct emissions of ozone, emissions of ozone precursor chemicals (i.e., NO_X and VOCs) can undergo chemical reactions when combined with other regional emissions to cause changes to ground-level ozone concentrations. The potential change in ambient air quality may affect other disciplines presented in Figure 1.7-1, and consequently, an impact analysis was conducted.

1.7.4 Project Case - Compliance with Relevant Provincial and Federal Guidelines

Whether the equipment and facilities incorporated in the design of the Project comply with relevant provincial and federal emission standards and guidelines has been identified as a key regional issue. The linkage diagram for Key Question AQPC-4 is presented in Figure 1.7-2. Since the Project will comply with standards and guidelines, an impact analysis was not required.

1.7.5 Project Case - Odours

The effect of industrial emissions on odour levels at the selected receptors has been identified as a key regional issue. Although mitigation measures that control fugitive emissions from the facility have been incorporated in the Project, odorous compounds may still be released and affect human health. Consequently an impact analysis was conducted. The linkage diagram for Key Question AQPC-5 is presented in Figure 1.7-1.

1.7.6 Project Case - Greenhouse Gas Emissions

How the Project will effect the emissions and management of greenhouse gases has been identified as a key regional issue. The linkage diagram for Key Question AQPC-6 is provided in Figure 1.7-3. The combustion of fuels during construction, operation and decommissioning of the Project will yield emissions of CO_2, CH_4 and N_2O, which are known greenhouse gases. Consequently, an assessment was conducted to delineate the effects of the Project on the production and management of greenhouse gas emissions.

1.7.7 Planned Development Case-Regional Air Emissions

The potential for emissions from the Planned Development Case to affect regional air quality is a key issue. Emissions from existing, approved and planned projects as well as the Project will change regional emissions and potentially ambient air quality, which in turn, may affect other disciplines as presented in Figure 1.7-1. Consequently, an impact analysis was conducted.

1.7.8 Planned Development Case-Acid Deposition

As in the Project Case, the deposition of sulphur and nitrogen compounds can result in long-term accumulations that have been associated with the acidification of terrestrial and aquatic ecosystems. For this reason, the effects of potential emissions of oxides of nitrogen (NO_X) and sulphur dioxide (SO_2) from the Project on acid deposition in the region are examined. Potential acid input was used to estimate acidification which takes into account the effects of sulphur and nitrogen species as well as the neutralizing effect of available base cations. The evaluation of acid-forming compounds from the Project was accomplished by predicting the regional PAI using the CALPUFF dispersion model.

Emissions from existing, approved and planned projects as well as the Project will change regional SO_2 and NO_X emissions and acid deposition, which in turn, may affect soils, vegetation and aquatic resources as shown in Figure 1.7-1. The evaluation of impacts that could result from PDC acid-forming emissions is provided in the Air Emissions Effects section (Section 4).

1.8 PROJECT CASE

1.8.1 Introduction

This section of the air quality assessment describes and quantifies the changes in air emissions, ground-level concentrations and regional deposition that could occur as a result of the Project. The air quality issues associated with these emissions have been summarized in a series of Key Questions.

1.8.2 Emissions

The evaluation of air quality changes associated with the Project requires consideration of emissions from other sources in the region in combination with those from the Project. Cumulative oil sands activities in the region have the potential to affect regional air quality. Table 1.8-1 summarizes the existing and approved oil sands developments that were included in the modelling domain of the Project Case. The table includes information on the location and distance of each development relative to the Project.

Table 1.8-1 Oil Sands Activities Included in the Project Case

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
MEG Energy Corp.			
Christina Lake Regional Project – Pilot	existing/approved	—	—
Christina Lake Regional Project – Commercial (Phases 2 and 2B)	approved	—	—
Christina Lake Regional Project – Commercial (Phases 3A and 3B)	—	—	—
EnCana FCLL Oil Sands Ltd.			
Christina Lake Thermal Project	existing/approved	14.49	SW
Foster Creek Pilot	existing/approved	67.03	S
Foster Creek Phases 1 and 2	existing/approved	67.59	S
Devon Canada Corporation			
Jackfish SAGD Project	approved	18.07	SSW
Petrobank			
Whitesands Pilot Project	existing/approved	33.63	W
ConocoPhillips Canada Resource Ltd.			
Surmont Commercial SAGD Project	approved	60.31	NNW
Petro-Canada Oil and Gas			
Meadow Creek In-Situ Project	approved	81.58	NNW
MacKay River In-Situ Project	approved	169.44	NNW
Dover SAGD Pilot and VAPEX Pilot	existing/approved	171.93	NNW
OPTI Canada Inc./Nexen Canada Ltd.			
Long Lake Pilot Project	existing/approved	83.29	N
Long Lake Commercial Project	approved	83.86	N
Connacher Oil and Gas Limited			
Great Divide Oil Sands Project	approved	85.41	NW
Canadian Natural Resources Limited			
Primrose North	approved	88.21	S
Burnt Lake Project	existing/approved	98.82	SSE
Primrose South	existing/approved	99.76	S
Primrose East In-Situ Oil Sands Project	approved	99.93	SSE
Wolf Lake	existing/approved	107.92	S
Horizon Oil Sands Project	approved	196.55	NNW
Japan Canada Oil Sands Limited			
Hangingstone In-Situ Pilot Project	existing/approved	92.97	NW
Imperial Oil Resources Limited			
Cold Lake In-Situ Project	existing/approved	115.34	S
Imperial Oil Resources Ventures Limited			
Kearl Oil Sands Project	approved	194.28	N
Husky Energy Inc.			
Tucker Thermal Project	existing/approved	122.77	S
Sunrise Thermal Project	approved	176.63	N
Shell Canada Limited			
Orion EOR Project	approved	127.20	S

Table 1.8-1 Oil Sands Activities Included in the Project Case (continued)

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
Jackpine Mine – Phase 1	approved	180.19	NNW
Suncor Energy Inc.			
South Tailings Pond	existing/approved	139.57	NNW
Lease 86/17, Steepbank & Millennium Mines	existing/approved	148.98	NNW
Voyageur Upgrader	approved	153.08	NNW
Upgrader Complex	existing/approved	156.44	NNW
North Steepbank Extension Mine	approved	156.46	NNW
Millennium Coker Unit (MCU)	approved	156.61	NNW
Millennium Vacuum Unit (MVU)	existing/approved	156.93	NNW
Firebag Enhanced Thermal Solvent (ETS) Pilot Project	existing/approved	172.60	N
Firebag SAGD Project	existing/approved	174.92	N
Syncrude Canada Ltd.			
Mildred Lake Mining and Upgrading, Upgrader Expansion and Emissions Reduction Program (ERP)	existing/approved	162.79	NNW
Aurora South Mine	approved	176.24	NNW
Aurora North Mine	existing/approved	188.12	NNW
Birch Mountain Resources Ltd.			
Muskeg Valley Quarry	existing/approved	176.89	NNW
Albian Sands Energy Inc.			
Muskeg River Mine and Muskeg River Mine Expansion	existing/approved	183.73	NNW
Total E&P Joslyn Ltd.			
Joslyn Creek SAGD Project – Phase 1 and Commercial	existing/approved	193.19	NNW
Petro-Canada Oil Sands Inc.			
Fort Hills Oil Sands Project	approved	199.03	NNW

[(a)] Distance and direction are relative to the Central Plant.

1.8.2.1 Project Emissions

MEG is proposing an expansion to its Christina Lake Regional Project (CLRP), in order to further develop its oil sands leases in the area. The Project will consist of two new plants and 138 new wellpads. Construction of the Project is anticipated to begin in 2010. The operational life of each plant is expected to be 25 years. Total incremental production will increase by 150,000 barrels per day (bpd) of bitumen. It is anticipated that reclamation of the Project will be complete by 2044. Continuous air emission sources from the Project include:

- fourteen (14) Once Through Steam Generators (OTSGs) fired on natural gas at each of the two phases;
- two (2) glycol heaters fired on sweetened produced gas at each of the two phases;
- two (2) slop treaters fired on sweetened produced gas at each of the two phases;

- two (2) amine preheaters fired on sweetened produced gas at each of the two phases;
- two (2) flares, each has a natural gas fired pilot running continuously at each of the two phases;
- one (1) Sulphur Recovery Unit (SRU) incinerator; and
- plant fugitives from tank losses as well as leaks from piping and other process equipment.

A summary of the SO_2, NO_X, CO, $PM_{2.5}$, VOC and TRS emission rates from the Project is presented in Table 1.8-2. The emissions presented in this table include both stream-day and calendar-day SO_2 emission rates. The SO_2 emission rates during normal operations are often referred to as “stream-day” emissions, when all pollution control and facility processes are on-stream and in operation. The average annual SO_2 release rates are often referred to as “calendar-day” rates and are determined by dividing the annual SO_2 emission rate from the facility by 365 days. A more detailed discussion of stream-day and calendar-day SO_2 emissions is presented in Appendix 3-II.

Table 1.8-2 Summary of Project Emissions

Source	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
steam generators	0.071	0.071	9.306	8.237	0.745	0.539	—
glycol heaters	0.003	0.003	0.219	0.298	0.027	0.020	—
slop treaters	0.000	0.000	0.032	0.044	0.004	0.003	—
amine preheaters	0.001	0.001	0.047	0.064	0.006	0.004	—
flare pilots	0.000	0.000	0.006	0.031	—	0.008	—
SRU incinerator	0.835	0.835	0.002	0.002	0.000	0.000	—
plant fugitives	—	—	—	—	—	0.021	0.043
Total[b]	**0.909**	**0.909**	**9.612**	**8.676**	**0.782**	**0.595**	**0.043**

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

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

A detailed summary of the emission parameters and rates from each individual source at the Project, can be found in Appendix 3-II, Section 3.

1.8.2.2 Summary of Project Case Emissions

Table 1.8-3 summarizes the Project Case emission rates included in the assessment. The Project Case emission rates include the EAC releases in combination with the Project emissions. A detailed summary of the emissions from the Project Case sources is presented in Appendix 3-II.

Table 1.8-3 Summary of Project Case Emissions – Modelling Domain

Source	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
MEG Energy Christina Lake Pilot	0.00	0.00	0.21	0.19	0.02	0.01	0.00
MEG Energy Christina Lake Phase 2	0.01	0.01	2.76	1.72	0.15	0.08	0.01
MEG Energy Christina Lake Phase 2B	1.52	1.52	3.52	2.41	0.21	0.12	0.01
MEG Energy Christina Lake Phases 3A and 3B	1.24	1.24	9.61	8.68	0.78	0.60	0.04
other industry south of Fort McMurray[b]	60.39	65.24	102.33	107.87	6.37	6.32[c]	0.25[c]
other industry north of Fort McMurray[b]	136.83	204.35	383.23	314.41	24.85	667.22[c]	7.38[c]
communities	0.19	0.19	0.92	—[d]	—[d]	2.13	0.00
Total[e]	**200.18**	**272.55**	**502.56**	**435.27**	**32.38**	**676.47**	**7.69**

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

[b] Includes the emissions from other oil sands developments and industrial sources in the modelling domain.

[c] Volatile Organic Compounds (VOCs) and Total Reduced Sulphur (TRS) emissions include variable pond emission rates from the Suncor, Canadian Natural and Imperial Oil developments as discussed in Appendix 3-II, Section 3.2. Emissions presented above include the maximum daily emission rates from these developments.

[d] Background data were added to model predictions to represent CO and $PM_{2.5}$ emissions from the communities. Therefore, community emissions of CO and $PM_{2.5}$ were not modelled. A description of the background data used is provided in Appendix 3-II, Section 2.3.9.

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

1.8.3 Key Question AQPC-1: What Effects Could the Project and the Existing and Approved Developments Have on Ambient Air Quality in the Region?

1.8.3.1 Impact Analysis

The first stage of the assessment examined the change in atmospheric emissions within the RSA that would result from the Project. These values are summarized in Table 1.8-4 for the key air quality parameters. When the EAC and Project Case emission rates within the RSA are compared, the Project results in an increase of 11.5% in SO_2, 36.2% in NO_X, 36.7% in CO, 58.7% in $PM_{2.5}$, 46.1% in VOCs and 51.9% in Total TRS.

Table 1.8-4 Comparison of the Existing and Approved Case and Project Case Air Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Change Due to Project[a] [%]
SO_2 emissions [t/sd]	10.81	12.06	11.5
SO_2 emissions [t/cd]	10.81	12.06	11.5
NO_X emissions [t/d]	26.52	36.14	36.2
CO emissions [t/d]	23.65	32.32	36.7
$PM_{2.5}$ emissions [t/d]	1.33	2.12	58.7
VOC emissions [t/d]	1.29	1.88	46.1
TRS emissions [t/d]	0.08	0.13	51.9

[a] Represents change between the EAC and Project Case.

The effect of emission rates associated with the Project on ground-level concentrations in the region were estimated using dispersion modelling. Concentrations of selected compounds (i.e., SO_2, NO_2, CO, H_2S, selected TRS compounds, benzene, selected VOCs, $PM_{2.5}$, selected PAH compounds and selected trace metals) were predicted using the CALPUFF model (3-D mode). The modelling results were compared to AAAQOs, Canadian Federal Air Quality Objectives, the CWS or other criteria, where applicable. Some parameters (e.g., VOCs, PAHs and trace metals) have the potential to affect the health of the people and wildlife in the region. The dispersion modelling results for these compounds have been assessed in the Human Health Assessment (Section 3). A summary of the Project Case predictions is provided in Appendix 3-III.

Table 1.8-5 compares the EAC and Project Case SO_2 maximum predictions (excluding developed areas) within the RSA and the LSA. The comparisons indicate that the Project emissions will increase maximum ambient SO_2 concentrations in the RSA and LSA. The maximum 1-hour, 24-hour and annual SO_2 concentrations remain below the AAAQO levels in both the RSA and LSA.

Table 1.8-5 Comparison of the Regional Existing and Approved Case and Project Case Sulphur Dioxide Predictions

Parameter	Existing and Approved Case	Project Case	Change Due to Project[a]
Local Study Area			
maximum 1-hour SO_2 (excluding developed areas)[b][c] [µg/m³]	283.1	416.1	133.0
occurrences above 1-hour AAAQO[d][e]	0	0	0
area above 1-hour AAAQO (excluding developed areas)[c][d] [ha]	0	0	0
maximum 24-hour SO_2 (excluding developed areas)[b][c] [µg/m³]	66.0	118.6	52.6
occurrences above 24-hour AAAQO[e][f]	0	0	0
area above 24-hour AAAQO (excluding developed areas)[c][f] [ha]	0	0	0
maximum annual average SO_2 (excluding developed areas)[b][c] [µg/m³]	7.4	15.6	8.2
occurrences above annual AAAQO[e][g]	0	0	0
area above annual AAAQO (excluding developed areas)[c][g] [ha]	0	0	0
Regional Study Area			
maximum 1-hour SO_2 (excluding developed areas)[b][c] [µg/m³]	283.1	416.1	133.0
occurrences above 1-hour AAAQO[d][e]	0	0	0
area above 1-hour AAAQO (excluding developed areas)[c][d] [ha]	0	0	0
maximum 24-hour SO_2 (excluding developed areas)[b][c] [µg/m³]	66.0	118.6	52.6
occurrences above 24-hour AAAQO[e][f]	0	0	0
area above 24-hour AAAQO (excluding developed areas)[c][f] [ha]	0	0	0
maximum annual average SO_2 (excluding developed areas)[b][c] [µg/m³]	7.4	15.6	8.2
occurrences above annual AAAQO[e][g]	0	0	0
area above annual AAAQO (excluding developed areas)[c][g] [ha]	0	0	0

[a] Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

[b] Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

[c] Developed areas include the Project plant sites.

[d] The 1-hour Alberta Ambient Air Quality Objective for SO_2 is 450 µg/m³.

[e] The number of occurrences is based on the concentrations outside of developed areas.

[f] The 24-hour Alberta Ambient Air Quality Objective for SO_2 is 150 µg/m³.

[g] The annual Alberta Ambient Air Quality Objective for SO_2 is 30 µg/m³.

Table 1.8-6 compares the EAC and Project Case ground-level NO_2 predicted concentrations (excluding developed areas) within the LSA and RSA. The comparisons indicate that the Project emissions will increase maximum ambient NO_2 concentrations in the RSA and LSA. The maximum 1-hour, 24-hour and annual NO_2 concentrations remain below the AAAQO levels in both the RSA and LSA.

In addition to evaluating the air quality across the region, the Project air quality assessment includes the ground-level concentrations of a range of compounds (i.e., SO_2, NO_2, CO, H_2S, selected TRS compounds, benzene, selected VOCs, $PM_{2.5}$, selected PAH compounds and selected trace metals) at the selected receptors. Some of these compounds have ambient air quality criteria that can be used to evaluate the possible effects of the air emissions from the Project on the air quality at the selected receptors. Modelling results of all compounds, including those without air quality guidelines and standards, were provided to other disciplines for evaluation. A summary of these evaluations has been presented in the Human Health Assessment (Section 3).

Table 1.8-6 Comparison of the Regional Existing and Approved Case and Project Case Nitrogen Dioxide Predictions

Parameter	Existing and Approved Case	Project Case	Change Due to Project[(a)]
Local Study Area			
maximum 1-hour NO_2 (excluding developed areas)(b)(c) [µg/m³]	87.9	161.4	73.5
occurrences above 1-hour AAAQO(d)(e)	0	0	0
area above 1-hour AAAQO (excluding developed areas)(c)(d) [ha]	0	0	0
maximum 24-hour NO_2 (excluding developed areas)(b)(c) [µg/m³]	41.8	46.4	4.6
occurrences above 24-hour AAAQO(e)(f)	0	0	0
area above 24-hour AAAQO (excluding developed areas)(c)(f) [ha]	0	0	0
maximum annual average NO_2 (excluding developed areas)(b)(c) [µg/m³]	3.8	6.1	2.2
occurrences above annual AAAQO(e)(g)	0	0	0
area above annual AAAQO (excluding developed areas)(c)(g) [ha]	0	0	0
Regional Study Area			
maximum 1-hour NO_2 (excluding developed areas)(b)(c) [µg/m³]	158.1	161.4	3.3
occurrences above 1-hour AAAQO(d)(e)	0	0	0
area above 1-hour AAAQO (excluding developed areas)(c)(d) [ha]	0	0	0
maximum 24-hour NO_2 (excluding developed areas)(b)(c) [µg/m³]	65.6	65.7	0.1
occurrences above 24-hour AAAQO(e)(f)	0	0	0
area above 24-hour AAAQO (excluding developed areas)(c)(f) [ha]	0	0	0
maximum annual average NO_2 (excluding developed areas)(b)(c) [µg/m³]	5.5	6.1	0.6
occurrences above annual AAAQO(e)(g)	0	0	0
area above annual AAAQO (excluding developed areas)(c)(g) [ha]	0	0	0

(a) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

(b) Maximum predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(c) Developed areas include the Project plant sites.

(d) The 1-hour Alberta Ambient Air Quality Objective for NO_2 is 400 µg/m³.

(e) The number of occurrences is based on the concentrations outside of developed areas.

(f) The 24-hour Alberta Ambient Air Quality Objective for NO_2 is 200 µg/m³.

(g) The annual Alberta Ambient Air Quality Objective for NO_2 is 60 µg/m³.

Table 1.8-7 presents the maximum and peak ambient ground-level SO_2 predicted concentrations at the selected receptors for the EAC and Project Case. Although emissions from the Project will result in an increase in SO_2 concentrations at the selected receptors, the predicted SO_2 concentrations at the selected receptors remain below the AAAQOs for the EAC and Project Case.

Table 1.8-8 presents the maximum and peak ambient ground-level NO_2 predicted concentrations at the selected receptors for the EAC and Project Case. Project emissions will result in an increase in NO_2 concentrations at the selected receptors; however, the predicted NO_2 concentrations at the selected receptors remain below the AAAQOs for the EAC and Project Case.

Tables 1.8-9 to 1.8-12 present the ambient ground-level CO, H_2S, COS and CS_2 concentrations, respectively, at the selected receptors for the EAC and Project Case. While the Project emissions result in an increase in the predicted ground-level concentrations at most of the selected receptors, the predictions at the selected receptors for CO, H_2S, COS and CS_2 remain below the AAAQOs or other applicable criteria.

Table 1.8-7 Comparison of the Existing and Approved Case and Project Case Sulphur Dioxide Predictions at Selected Receptors

Receptor	Maximum 1-Hour SO_2[(a)(b)]				Peak 24-Hour SO_2[(a)(c)]				Peak Annual Average SO_2[(a)(d)]			
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(e)]	% of AAAQO	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(e)]	% of AAAQO	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(e)]	% of AAAQO
Conklin	17.3	17.8	0.5	4	9.3	9.9	0.5	7	1.16	1.20	0.03	4
Janvier/Chard (IR 194)	25.6	25.6	0.0	6	13.4	13.4	0.0	9	1.49	1.52	0.03	5
Winefred Lake (IR 194B)	18.4	19.0	0.6	4	10.4	11.3	0.9	8	1.68	1.82	0.15	6
Hunter/Trapper A	60.8	60.8	0.0	14	19.6	19.9	0.3	13	2.52	2.70	0.18	9
Hunter/Trapper B	22.8	24.7	1.8	5	12.0	12.0	0.0	8	1.40	1.46	0.07	5
Operator's Residence	46.4	46.4	0.0	10	23.8	23.8	0.0	16	2.51	2.78	0.28	9
Christina Lake Lodge	19.9	20.6	0.7	5	9.5	9.9	0.4	7	1.15	1.19	0.04	4
Maximum Property Boundary	281.6	416.1	134.6	92	66.0	118.5	52.6	79	6.53	15.63	9.11	52

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the peak 24-hour and annual values.

(b) The 1-hour Alberta Ambient Air Quality Objective for SO_2 is 450 µg/m³.

(c) The 24-hour Alberta Ambient Air Quality Objective for SO_2 is 150 µg/m³.

(d) The annual Alberta Ambient Air Quality Objective for SO_2 is 30 µg/m³.

(e) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Table 1.8-8 Comparison of the Existing and Approved Case and Project Case Nitrogen Dioxide Predictions at Selected Receptors

Receptor	Maximum 1-Hour NO$_2$(a)(b)				Peak 24-Hour NO$_2$(a)(c)				Peak Annual Average NO$_2$(a)(d)			
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project [µg/m^3](e)	% of AAAQO	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project [µg/m^3](e)	% of AAAQO	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(e) [µg/m^3]	% of AAAQO
Conklin	84.4	84.4	0.0	21	31.0	31.3	0.3	16	3.72	3.93	0.21	7
Janvier/Chard (IR 194)	56.7	56.7	0.0	14	24.7	24.8	0.1	12	3.84	3.99	0.15	7
Winefred Lake (IR 194B)	20.6	54.1	33.5	14	11.5	18.4	6.8	9	2.26	3.83	1.57	6
Hunter/Trapper A	26.9	29.5	2.7	7	11.7	13.0	1.3	6	2.58	3.03	0.46	5
Hunter/Trapper B	29.9	31.3	1.4	8	14.9	15.0	0.1	8	2.24	2.92	0.68	5
Operator's Residence	31.1	31.8	0.7	8	12.0	13.3	1.3	7	2.72	3.23	0.51	5
Christina Lake Lodge	37.1	37.1	0.0	9	13.2	13.2	0.0	7	2.27	2.50	0.23	4
Maximum Property Boundary	84.8	156.1	71.3	39	41.8	44.6	2.8	22	3.77	5.07	1.30	8

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the peak 24-hour and annual values.

(b) The 1-hour Alberta Ambient Air Quality Objective for NO$_2$ is 400 µg/m^3.

(c) The 24-hour Alberta Ambient Air Quality Objective for NO$_2$ is 200 µg/m^3.

(d) The annual Alberta Ambient Air Quality Objective for NO$_2$ is 60 µg/m^3.

(e) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Table 1.8-9 Comparison of the Existing and Approved Case and Project Case Carbon Monoxide Predictions at Selected Receptors

Receptor	Peak 1-Hour CO[a][b]				Peak 8-Hour CO[a][c]			
	Existing and Approved Case [µg/m³]	**Project Case [µg/m³]**	**Change Due to Project [µg/m³][d]**	**% of AAAQO**	**Existing and Approved Case [µg/m³]**	**Project Case [µg/m³]**	**Change Due to Project [µg/m³][d]**	**% of AAAQO**
Conklin	347.7	347.7	0.0	2	164.9	165.0	0.1	3
Janvier/Chard (IR 194)	421.7	421.8	0.0	3	255.7	255.7	0.0	4
Winefred Lake (IR 194B)	45.7	80.9	35.2	1	34.0	43.5	9.4	1
Hunter/Trapper A	46.9	47.2	0.3	0	28.4	30.7	2.2	1
Hunter/Trapper B	55.6	55.6	0.1	0	43.3	43.3	0.1	1
Operator’s Residence	55.5	55.6	0.0	0	30.0	32.7	2.7	1
Christina Lake Lodge	58.4	58.4	0.0	0	27.4	27.6	0.2	0
Maximum Property Boundary	433.2	1,153.2	720.0	8	129.9	370.0	240.1	6

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

(b) The 1-hour Alberta Ambient Air Quality Objective for CO is 15,000 µg/m³.

(c) The 8-hour Alberta Ambient Air Quality Objective for CO is 6,000 µg/m³.

(d) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Note: There is no annual Alberta Ambient Air Quality Objective for CO.

Table 1.8-10 Comparison of the Existing and Approved Case and Project Case Hydrogen Sulphide Predictions at Selected Receptors

Receptor	Peak 1-Hour H_2S[(a)(b)]				Peak 24-Hour H_2S[(a)(c)]			
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(d)]	% of AAAQO	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(d)]	% of AAAQO
Conklin	0.85	0.85	0.00	6	0.13	0.13	0.00	3
Janvier/Chard (IR 194)	0.18	0.18	0.00	1	0.06	0.06	0.00	2
Winefred Lake (IR 194B)	0.14	0.39	0.25	3	0.05	0.15	0.10	4
Hunter/Trapper A	0.21	0.23	0.02	2	0.08	0.09	0.01	2
Hunter/Trapper B	0.21	0.23	0.03	2	0.05	0.05	0.00	1
Operator’s Residence	0.42	0.42	0.00	3	0.14	0.15	0.01	4
Christina Lake Lodge	0.34	0.34	0.00	2	0.08	0.08	0.00	2
Maximum Property Boundary	5.97	8.33	2.36	60	2.49	3.55	1.06	89

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

(b) The 1-hour Alberta Ambient Air Quality Objective for H_2S is 14 µg/m³.

(c) The 24-hour Alberta Ambient Air Quality Objective for H_2S is 4 µg/m³.

(d) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Note: There is no annual Alberta Ambient Air Quality Objective for H_2S.

Table 1.8-11 Comparison of the Existing and Approved Case and Project Case Carbonyl Sulphide Predictions at Selected Receptors

Receptor	Peak 1-Hour COS[(a)]			Peak Annual Average COS[(a)]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(b)]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(b)]
Conklin	0.015	0.015	0.000	0.001	0.001	0.000
Janvier/Chard (IR 194)	0.042	0.042	0.000	0.001	0.001	0.000
Winefred Lake (IR 194B)	0.022	0.022	0.000	0.001	0.001	0.000
Hunter/Trapper A	0.020	0.020	0.000	0.001	0.001	0.000
Hunter/Trapper B	0.030	0.030	0.000	0.001	0.001	0.000
Operator's Residence	0.020	0.020	0.000	0.001	0.001	0.000
Christina Lake Lodge	0.017	0.017	0.000	0.001	0.001	0.000
Maximum Property Boundary	0.215	0.299	0.084	0.010	0.018	0.008

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

(b) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Note: There are no Alberta Ambient Air Quality Objectives for COS.

Table 1.8-12 Comparison of the Existing and Approved Case and Project Case Carbon Disulphide Predictions at Selected Receptors

Receptor	Peak 1-Hour CS_2[a][b]				Peak Annual Average CS_2[a]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][c]	% of AAAQO	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project Case [µg/m³][c]
Conklin	0.015	0.015	0.000	0.0	0.001	0.001	0.000
Janvier/Chard (IR 194)	0.040	0.040	0.000	0.1	0.001	0.001	0.000
Winefred Lake (IR 194B)	0.021	0.024	0.004	0.1	0.001	0.001	0.000
Hunter/Trapper A	0.019	0.019	0.000	0.1	0.001	0.001	0.000
Hunter/Trapper B	0.029	0.029	0.000	0.1	0.001	0.001	0.000
Operator's Residence	0.024	0.025	0.000	0.1	0.001	0.001	0.000
Christina Lake Lodge	0.015	0.015	0.000	0.1	0.001	0.001	0.000
Maximum Property Boundary	0.347	0.484	0.137	1.6	0.015	0.028	0.013

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

[b] The 1-hour Alberta Ambient Air Quality Objective for CS_2 is 30 µg/m³.

[c] Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Note: There are no 24-hour or annual Alberta Ambient Air Quality Objectives for CS_2.

Table 1.8-13 presents the predicted ambient ground-level benzene concentrations at the selected receptors for EAC and Project Case. The modelling results indicate that the Project results in no change to 1-hour benzene concentrations, and the ground-level benzene concentrations EAC for the Project Case are below the AAAQO.

Table 1.8-13 Comparison of the Existing and Approved Case and Project Case Benzene Predictions at Selected Receptors

Receptor	Peak 1-Hour Benzene[a][b]			
	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Change Due to Project [μg/m³][c]	% of AAAQO
Conklin	0.6	0.6	0.0	2
Janvier/Chard (IR 194)	0.4	0.4	0.0	1
Winefred Lake (IR 194B)	0.2	0.2	0.0	1
Hunter/Trapper A	0.3	0.3	0.0	1
Hunter/Trapper B	0.3	0.3	0.0	1
Operator's Residence	0.3	0.3	0.0	1
Christina Lake Lodge	0.2	0.2	0.0	1
Maximum Property Boundary	0.3	0.3	0.0	1

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

(b) The 1-hour Alberta Ambient Air Quality Objective for benzene is 30 μg/m³.

(c) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Note: There are no 24-hour or annual Alberta Ambient Air Quality Objectives for benzene.

Table 1.8-14 presents the predicted ambient ground-level VOC concentrations at the selected receptors for the EAC and Project Case. For most VOC species, the Project emissions result in a small incremental effect on predicted concentrations at the selected receptors. For select compounds at a few of the selected receptors, the VOC predictions decreased slightly (i.e., at the fourth or fifth decimal place) from the EAC to the Project Case. This is likely due to rounding errors. The predicted VOC concentrations remain below the AAAQOs or other criteria, as applicable.

Table 1.8-14 Comparison of the Existing and Approved Case and Project Case Volatile Organic Compound Predictions at Selected Receptors

Averaging Period and Parameter(a)(b)	Conklin			Janvier/Chard (IR 194)		
	Existing and Approved Case [µg/m^3]	**Project Case [µg/m^3]**	**Change Due to Project [µg/m^3](c)**	**Existing and Approved Case [µg/m^3]**	**Project Case [µg/m^3]**	**Change Due to Project [µg/m^3](c)**
Peak 1-hour benzene	0.579080	0.579110	0.000030	0.411930	0.411930	0.000000
Peak 1-hour trimethylbenzene	0.287960	0.287960	0.000000	0.622800	0.622800	0.000000
Peak annual trimethylbenzene	0.006897	0.006897	0.000000	0.009776	0.009776	0.000000
Peak 1-hour hexane	4.637600	4.637600	0.000000	17.823000	17.823000	0.000000
Peak annual hexane	0.124958	0.128590	0.003632	0.210808	0.213593	0.002785
Peak 1-hour acrolein	0.338960	0.338960	0.000000	0.086463	0.086462	-0.000001
Peak annual acrolein	0.007036	0.007036	0.000000	0.003439	0.003439	0.000000
Peak 1-hour 1,3-butadiene	0.017802	0.017802	0.000000	0.007747	0.007747	0.000000
Peak annual 1,3-butadiene	0.000521	0.000521	0.000000	0.000264	0.000264	0.000000
Peak 1-hour formaldehyde	3.483600	3.483700	0.000100	0.626500	0.626510	0.000010
Peak 1-hour 1,1,1-trichloroethane	0.000128	0.000128	0.000000	0.000017	0.000017	0.000000
Peak annual 1,1,1-trichloroethane	0.000006	0.000006	0.000000	0.000001	0.000001	0.000000
Peak 1-hour acetaldehyde	0.843290	0.843290	0.000000	1.026100	1.026100	0.000000
Peak 1-hour acetone	0.428360	0.428360	0.000000	0.536420	0.536420	0.000000
Peak 1-hour cumene	0.402190	0.402190	0.000000	1.065000	1.065100	0.000100
Peak 1-hour ethylbenzene	1.347900	1.347900	0.000000	2.471700	2.471700	0.000000
Peak 1-hour ethylene	2.241800	2.241800	0.000000	0.255230	0.255230	0.000000
Peak annual ethylene	0.106981	0.106989	0.000008	0.022616	0.022619	0.000003
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	1.958900	1.958900	0.000000	4.288700	4.288700	0.000000
Peak 1-hour xylenes	2.110400	2.110400	0.000000	5.599900	5.599900	0.000000
Peak 1-hour 1,1,2-trichloroethanes	0.002066	0.002066	0.000000	0.000210	0.000210	0.000000
Peak annual 1,1,2-trichloroethanes	0.000019	0.000019	0.000000	0.000008	0.000008	0.000000
Peak 1-hour 1,2-dichloropropane	0.001748	0.001748	0.000000	0.000178	0.000178	0.000000
Peak annual 1,2-dichloropropane	0.000016	0.000016	0.000000	0.000007	0.000007	0.000000
Peak 1-hour 1,3-dichloropropene	0.001715	0.001715	0.000000	0.000174	0.000174	0.000000
Peak annual 1,3-dichloropropene	0.000016	0.000016	0.000000	0.000006	0.000006	0.000000
Peak 1-hour carbon tetrachloride	0.002384	0.002384	0.000000	0.000242	0.000242	0.000000
Peak annual carbon tetrachloride	0.000022	0.000022	0.000000	0.000009	0.000009	0.000000
Peak 1-hour chlorobenzene	0.001975	0.001975	0.000000	0.000201	0.000201	0.000000
Peak annual chlorobenzene	0.000018	0.000018	0.000000	0.000007	0.000007	0.000000
Peak 1-hour chloroethane	0.000121	0.000121	0.000000	0.000012	0.000012	0.000000
Peak annual chloroethane	0.000001	0.000001	0.000000	0.000000	0.000000	0.000000
Peak 1-hour chloroform	0.001852	0.001852	0.000000	0.000188	0.000188	0.000000
Peak annual chloroform	0.000017	0.000017	0.000000	0.000007	0.000007	0.000000
Peak 1-hour methanol	0.162410	0.162410	0.000000	0.016513	0.016513	0.000000
Peak 1-hour methylene chloride	0.001299	0.001299	0.000000	0.000132	0.000132	0.000000
Peak annual methylene chloride	0.000012	0.000012	0.000000	0.000005	0.000005	0.000000
Peak 1-hour phenol	0.001559	0.001559	0.000000	0.000159	0.000159	0.000000
Peak 1-hour vinyl chloride	0.000968	0.000968	0.000000	0.000098	0.000098	0.000000
Peak 1-hour styrene	0.001533	0.001533	0.000000	0.000156	0.000156	0.000000
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.001147	0.001147	0.000000	0.001597	0.001597	0.000000
Peak annual propylene oxide	0.000040	0.000040	0.000000	0.000056	0.000056	0.000000

Table 1.8-14 Comparison of the Existing and Approved Case and Project Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter$^{(a)(b)}$	Winefred Lake (IR 194B)			Hunter/Trapper A		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project [µg/m^3]$^{(c)}$	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project [µg/m^3]$^{(c)}$
Peak 1-hour benzene	0.196200	0.196200	0.000000	0.264080	0.264090	0.000010
Peak 1-hour trimethylbenzene	0.334320	0.334320	0.000000	0.456950	0.456950	0.000000
Peak annual trimethylbenzene	0.006492	0.006493	0.000000	0.006501	0.006501	0.000000
Peak 1-hour hexane	8.058300	8.059000	0.000700	10.853000	10.860000	0.007000
Peak annual hexane	0.144294	0.169286	0.024993	0.145776	0.153390	0.007614
Peak 1-hour acrolein	0.041927	0.041926	-0.000001	0.039168	0.039168	0.000000
Peak annual acrolein	0.002025	0.002025	0.000000	0.002312	0.002312	0.000000
Peak 1-hour 1,3-butadiene	0.003768	0.003768	0.000000	0.003519	0.003519	0.000000
Peak annual 1,3-butadiene	0.000151	0.000151	0.000000	0.000165	0.000165	0.000000
Peak 1-hour formaldehyde	0.312890	0.316400	0.003510	0.327990	0.328270	0.000280
Peak 1-hour 1,1,1-trichloroethane	0.000028	0.000028	0.000000	0.000022	0.000022	0.000000
Peak annual 1,1,1-trichloroethane	0.000001	0.000001	0.000000	0.000001	0.000001	0.000000
Peak 1-hour acetaldehyde	0.500580	0.500580	0.000000	0.467260	0.467260	0.000000
Peak 1-hour acetone	0.261740	0.261740	0.000000	0.244600	0.244600	0.000000
Peak 1-hour cumene	0.595830	0.595830	0.000000	0.668140	0.668140	0.000000
Peak 1-hour ethylbenzene	1.468500	1.468500	0.000000	1.320800	1.320800	0.000000
Peak 1-hour ethylene	0.122380	0.122410	0.000030	0.115080	0.115090	0.000010
Peak annual ethylene	0.004025	0.004077	0.000053	0.004141	0.004156	0.000015
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	2.335000	2.335100	0.000100	3.116900	3.116900	0.000000
Peak 1-hour xylenes	2.799900	2.799900	0.000000	2.974500	2.974500	0.000000
Peak 1-hour 1,1,2-trichloroethanes	0.000132	0.000132	0.000000	0.000177	0.000177	0.000000
Peak annual 1,1,2-trichloroethanes	0.000005	0.000005	0.000000	0.000007	0.000007	0.000000
Peak 1-hour 1,2-dichloropropane	0.000112	0.000112	0.000000	0.000150	0.000150	0.000000
Peak annual 1,2-dichloropropane	0.000004	0.000004	0.000000	0.000006	0.000006	0.000000
Peak 1-hour 1,3-dichloropropene	0.000110	0.000110	0.000000	0.000147	0.000147	0.000000
Peak annual 1,3-dichloropropene	0.000004	0.000004	0.000000	0.000006	0.000006	0.000000
Peak 1-hour carbon tetrachloride	0.000153	0.000153	0.000000	0.000205	0.000205	0.000000
Peak annual carbon tetrachloride	0.000006	0.000006	0.000000	0.000008	0.000008	0.000000
Peak 1-hour chlorobenzene	0.000126	0.000126	0.000000	0.000170	0.000170	0.000000
Peak annual chlorobenzene	0.000005	0.000005	0.000000	0.000007	0.000007	0.000000
Peak 1-hour chloroethane	0.000008	0.000008	0.000000	0.000010	0.000010	0.000000
Peak annual chloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour chloroform	0.000119	0.000119	0.000000	0.000159	0.000159	0.000000
Peak annual chloroform	0.000005	0.000005	0.000000	0.000006	0.000006	0.000000
Peak 1-hour methanol	0.010402	0.010402	0.000000	0.013950	0.013950	0.000000
Peak 1-hour methylene chloride	0.000083	0.000083	0.000000	0.000112	0.000112	0.000000
Peak annual methylene chloride	0.000003	0.000003	0.000000	0.000004	0.000004	0.000000
Peak 1-hour phenol	0.000100	0.000100	0.000000	0.000134	0.000134	0.000000
Peak 1-hour vinyl chloride	0.000062	0.000062	0.000000	0.000083	0.000083	0.000000
Peak 1-hour styrene	0.000098	0.000098	0.000000	0.000132	0.000132	0.000000
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.002176	0.002176	0.000000	0.005201	0.005201	0.000000
Peak annual propylene oxide	0.000084	0.000084	0.000000	0.000069	0.000069	0.000000

Table 1.8-14 Comparison of the Existing and Approved Case and Project Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter(a)(b)	Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project [µg/m^3](c)	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project [µg/m^3](c)
Peak 1-hour benzene	0.272570	0.272580	0.000010	0.262450	0.262450	0.000000
Peak 1-hour trimethylbenzene	0.457470	0.457470	0.000000	0.449750	0.449750	0.000000
Peak annual trimethylbenzene	0.007911	0.007911	0.000000	0.006605	0.006605	0.000000
Peak 1-hour hexane	11.223000	11.223000	0.000000	10.834000	10.835000	0.001000
Peak annual hexane	0.170074	0.180786	0.010712	0.149937	0.158384	0.008447
Peak 1-hour acrolein	0.059498	0.059498	0.000000	0.039611	0.039611	0.000000
Peak annual acrolein	0.002635	0.002635	0.000000	0.002309	0.002309	0.000000
Peak 1-hour 1,3-butadiene	0.005353	0.005353	0.000000	0.003568	0.003568	0.000000
Peak annual 1,3-butadiene	0.000191	0.000191	0.000000	0.000166	0.000166	0.000000
Peak 1-hour formaldehyde	0.426300	0.426330	0.000030	0.352890	0.353200	0.000310
Peak 1-hour 1,1,1-trichloroethane	0.000021	0.000021	0.000000	0.000023	0.000023	0.000000
Peak annual 1,1,1-trichloroethane	0.000000	0.000000	0.000000	0.000001	0.000001	0.000000
Peak 1-hour acetaldehyde	0.712080	0.712070	-0.000010	0.475210	0.475210	0.000000
Peak 1-hour acetone	0.372690	0.372680	-0.000010	0.248980	0.248980	0.000000
Peak 1-hour cumene	0.762030	0.762030	0.000000	0.670260	0.670260	0.000000
Peak 1-hour ethylbenzene	1.913100	1.913100	0.000000	1.363600	1.363600	0.000000
Peak 1-hour ethylene	0.176070	0.176070	0.000000	0.117260	0.117260	0.000000
Peak annual ethylene	0.004845	0.004867	0.000021	0.004190	0.004208	0.000018
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	3.159800	3.159800	0.000000	3.073800	3.073800	0.000000
Peak 1-hour xylenes	4.119700	4.119700	0.000000	3.024000	3.024000	0.000000
Peak 1-hour 1,1,2-trichloroethanes	0.000198	0.000198	0.000000	0.000192	0.000192	0.000000
Peak annual 1,1,2-trichloroethanes	0.000008	0.000008	0.000000	0.000007	0.000007	0.000000
Peak 1-hour 1,2-dichloropropane	0.000167	0.000167	0.000000	0.000163	0.000163	0.000000
Peak annual 1,2-dichloropropane	0.000006	0.000006	0.000000	0.000006	0.000006	0.000000
Peak 1-hour 1,3-dichloropropene	0.000164	0.000164	0.000000	0.000160	0.000160	0.000000
Peak annual 1,3-dichloropropene	0.000006	0.000006	0.000000	0.000006	0.000006	0.000000
Peak 1-hour carbon tetrachloride	0.000228	0.000228	0.000000	0.000222	0.000222	0.000000
Peak annual carbon tetrachloride	0.000009	0.000009	0.000000	0.000008	0.000008	0.000000
Peak 1-hour chlorobenzene	0.000189	0.000189	0.000000	0.000184	0.000184	0.000000
Peak annual chlorobenzene	0.000007	0.000007	0.000000	0.000007	0.000007	0.000000
Peak 1-hour chloroethane	0.000012	0.000012	0.000000	0.000011	0.000011	0.000000
Peak annual chloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour chloroform	0.000177	0.000177	0.000000	0.000172	0.000172	0.000000
Peak annual chloroform	0.000007	0.000007	0.000000	0.000006	0.000006	0.000000
Peak 1-hour methanol	0.015554	0.015554	0.000000	0.015116	0.015116	0.000000
Peak 1-hour methylene chloride	0.000124	0.000124	0.000000	0.000121	0.000121	0.000000
Peak annual methylene chloride	0.000005	0.000005	0.000000	0.000004	0.000004	0.000000
Peak 1-hour phenol	0.000149	0.000149	0.000000	0.000145	0.000145	0.000000
Peak 1-hour vinyl chloride	0.000093	0.000093	0.000000	0.000090	0.000090	0.000000
Peak 1-hour styrene	0.000147	0.000147	0.000000	0.000143	0.000143	0.000000
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.002566	0.002566	0.000000	0.012848	0.012848	0.000000
Peak annual propylene oxide	0.000059	0.000059	0.000000	0.000088	0.000088	0.000000

Table 1.8-14 Comparison of the Existing and Approved Case and Project Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter[(a)(b)]	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(c)]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][(c)]
Peak 1-hour benzene	0.170360	0.170360	0.000000	0.252110	0.252110	0.000000
Peak 1-hour trimethylbenzene	0.361050	0.361050	0.000000	0.441250	0.441260	0.000010
Peak annual trimethylbenzene	0.005956	0.005956	0.000000	0.007166	0.007183	0.000017
Peak 1-hour hexane	6.420500	6.420500	0.000000	10.885000	16.695000	5.810000
Peak annual hexane	0.123859	0.127869	0.004010	0.270195	0.358152	0.087957
Peak 1-hour acrolein	0.089542	0.089542	0.000000	0.171360	0.171360	0.000000
Peak annual acrolein	0.003071	0.003071	0.000000	0.003673	0.003673	0.000000
Peak 1-hour 1,3-butadiene	0.004804	0.004804	0.000000	0.008939	0.008939	0.000000
Peak annual 1,3-butadiene	0.000203	0.000203	0.000000	0.000240	0.000240	0.000000
Peak 1-hour formaldehyde	0.909690	0.909730	0.000040	2.124200	2.126500	0.002300
Peak 1-hour 1,1,1-trichloroethane	0.000021	0.000021	0.000000	0.000028	0.000028	0.000000
Peak annual 1,1,1-trichloroethane	0.000001	0.000001	0.000000	0.000001	0.000001	0.000000
Peak 1-hour acetaldehyde	0.357890	0.357890	0.000000	0.549310	0.549310	0.000000
Peak 1-hour acetone	0.187110	0.187110	0.000000	0.287160	0.287160	0.000000
Peak 1-hour cumene	0.506020	0.506020	0.000000	0.671680	0.671680	0.000000
Peak 1-hour ethylbenzene	1.225500	1.225500	0.000000	2.554100	2.554100	0.000000
Peak 1-hour ethylene	0.111600	0.111610	0.000010	0.135690	0.150420	0.014730
Peak annual ethylene	0.005304	0.005313	0.000009	0.006743	0.009022	0.002279
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	2.453500	2.453500	0.000000	3.005000	3.021500	0.016500
Peak 1-hour xylenes	2.113800	2.113800	0.000000	3.367200	3.368700	0.001500
Peak 1-hour 1,1,2-	0.000530	0.000530	0.000000	0.001054	0.001054	0.000000
Peak annual 1,1,2-	0.000012	0.000012	0.000000	0.000015	0.000015	0.000000
Peak 1-hour 1,2-dichloropropane	0.000448	0.000448	0.000000	0.000892	0.000892	0.000000
Peak annual 1,2-dichloropropane	0.000010	0.000010	0.000000	0.000013	0.000013	0.000000
Peak 1-hour 1,3-dichloropropene	0.000440	0.000440	0.000000	0.000875	0.000875	0.000000
Peak annual 1,3-dichloropropene	0.000010	0.000010	0.000000	0.000012	0.000012	0.000000
Peak 1-hour carbon tetrachloride	0.000612	0.000612	0.000000	0.001216	0.001216	0.000000
Peak annual carbon tetrachloride	0.000014	0.000014	0.000000	0.000017	0.000017	0.000000
Peak 1-hour chlorobenzene	0.000507	0.000507	0.000000	0.001008	0.001008	0.000000
Peak annual chlorobenzene	0.000012	0.000012	0.000000	0.000014	0.000014	0.000000
Peak 1-hour chloroethane	0.000031	0.000031	0.000000	0.000062	0.000062	0.000000
Peak annual chloroethane	0.000001	0.000001	0.000000	0.000001	0.000001	0.000000
Peak 1-hour chloroform	0.000475	0.000475	0.000000	0.000945	0.000945	0.000000
Peak annual chloroform	0.000011	0.000011	0.000000	0.000013	0.000013	0.000000
Peak 1-hour methanol	0.041656	0.041656	0.000000	0.082866	0.082866	0.000000
Peak 1-hour methylene chloride	0.000333	0.000333	0.000000	0.000663	0.000663	0.000000
Peak annual methylene chloride	0.000008	0.000008	0.000000	0.000009	0.000009	0.000000
Peak 1-hour phenol	0.000400	0.000400	0.000000	0.000796	0.000796	0.000000
Peak 1-hour vinyl chloride	0.000248	0.000248	0.000000	0.000494	0.000494	0.000000
Peak 1-hour styrene	0.000393	0.000393	0.000000	0.000782	0.000782	0.000000
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.000966	0.000966	0.000000	0.081733	0.081733	0.000000
Peak annual propylene oxide	0.000041	0.000041	0.000000	0.000738	0.000738	0.000000

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

[(b)] See Table 1.2-4 for respective air quality guidelines.

[(c)] Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Table 1.8-15 provides a comparison of the predicted $PM_{2.5}$ concentrations at the selected receptors. In this assessment, monitored data were used to represent the ground-level $PM_{2.5}$ concentrations within the communities resulting from community sources (Appendix 3-II). While the Project emissions result in an increase in predicted peak 1-hour and 24-hour $PM_{2.5}$ concentrations at most of the selected receptors, the $PM_{2.5}$ concentrations at the selected receptors remain below the AAAQO for both the EAC and the Project Case. However, the peak predicted 1-hour $PM_{2.5}$ concentration at the Maximum Property Boundary is above the 80 $\mu g/m^3$ AAAQO for the Project Case.

Table 1.8-16 presents the predicted ambient ground-level PAH concentrations at the selected receptors for the EAC and Project Case. Predicted 1-hour and annual trace metals concentrations at the selected receptors have been presented in Tables 1.8-17 and 1.8-18, respectively, for the EAC and Project Case. For most compounds, the Project emissions result in a small incremental increase in predicted concentrations at the selected receptors. All of the predicted PAH and metal concentrations remain below AAAQO levels or other criteria, as applicable.

Table 1.8-15 Comparison of the Existing and Approved Case and Project Case Particulate Matter Predictions at Selected Receptors

Receptor	Peak 1-Hour $PM_{2.5}$ [a][b]				Peak 24-Hour $PM_{2.5}$ [a][c]			
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project[d] [µg/m³]	% of AAAQO	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project [µg/m³][d]	% of AAAQO
Conklin	24.5	24.6	0.1	31	16.9	17.1	0.2	57
Janvier/Chard (IR 194)	54.2	54.2	0.0	68	21.8	22.0	0.2	73
Winefred Lake (IR 194B)	34.3	34.4	0.0	43	13.8	14.5	0.7	48
Hunter/Trapper A	26.9	27.3	0.4	34	13.1	13.6	0.5	45
Hunter/Trapper B	37.0	37.0	0.0	46	14.6	14.9	0.2	50
Operator’s Residence	28.3	29.1	0.8	36	13.3	13.8	0.5	46
Christina Lake Lodge	18.5	18.5	0.1	23	11.5	11.7	0.2	39
Maximum Property Boundary	45.6	**101.2**[e]	55.6	127	16.2	19.5	3.3	65

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

[b] The 1-hour Alberta Ambient Air Quality Objective for $PM_{2.5}$ is 80 µg/m³.

[c] The 24-hour Alberta Ambient Air Quality Objective for $PM_{2.5}$ is 30 µg/m³.

[d] Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

[e] The maximum 1-hour $PM_{2.5}$ concentration (i.e., excluding the eight highest 1-hour predicted concentrations) is estimated to be 45.9 µg/m³.

Table 1.8-16 Comparison of the Existing and Approved Case and Project Case Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors

Averaging Period and Parameter(a)	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]
peak 1-hour pyrenes and substitutes	0.000090	0.000090	0.000000	0.000117	0.000117	0.000000	0.000064	0.000066	0.000003
peak annual pyrenes and substitutes	0.000003	0.000003	0.000000	0.000003	0.000003	0.000000	0.000003	0.000004	0.000001
peak 1-hour fluorenes/fluoranthenes and substitutes	0.000446	0.000446	0.000000	0.000340	0.000340	0.000000	0.000193	0.000198	0.000005
peak annual fluorenes/fluoranthenes and substitutes	0.000010	0.000010	0.000000	0.000010	0.000010	0.000000	0.000007	0.000009	0.000002
peak 1-hour acenaphthenes/ acenaphthylenes	0.000445	0.000445	0.000000	0.000177	0.000178	0.000000	0.000096	0.000097	0.000001
peak annual acenaphthenes/ acenaphthylenes	0.000007	0.000007	0.000000	0.000006	0.000006	0.000000	0.000004	0.000005	0.000001
peak 1-hour anthracenes/ phenanthrenes and substitutes	0.000686	0.000686	0.000000	0.000409	0.000409	0.000000	0.000225	0.000239	0.000014
peak annual anthracenes/ phenanthrenes and substitutes	0.000013	0.000014	0.000001	0.000012	0.000013	0.000000	0.000010	0.000015	0.000005
peak 1-hour naphthalene and substitutes	0.007160	0.007169	0.000010	0.005550	0.005552	0.000002	0.003598	0.006911	0.003314
peak annual naphthalene and substitutes	0.000190	0.000217	0.000028	0.000186	0.000202	0.000016	0.000184	0.000349	0.000165
peak 1-hour biphenyl	0.013893	0.013893	0.000000	0.001412	0.001412	0.000000	0.000890	0.000890	0.000000
peak annual biphenyl	0.000127	0.000127	0.000000	0.000053	0.000053	0.000000	0.000035	0.000035	0.000000

Table 1.8-16 Comparison of the Existing and Approved Case and Project Case Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Averaging Period and Parameter[a]	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project[b] [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project[b] [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project[b] [µg/m^3]
peak 1-hour pyrenes and substitutes	0.000077	0.000077	0.000000	0.000085	0.000085	0.000000	0.000122	0.000122	0.000000
peak annual pyrenes and substitutes	0.000003	0.000004	0.000000	0.000003	0.000004	0.000001	0.000004	0.000004	0.000000
peak 1-hour fluorenes/fluoranthenes and substitutes	0.000197	0.000198	0.000000	0.000264	0.000264	0.000000	0.000195	0.000195	0.000000
peak annual fluorenes/fluoranthenes and substitutes	0.000008	0.000009	0.000000	0.000009	0.000009	0.000001	0.000009	0.000009	0.000001
peak 1-hour acenaphthenes/ acenaphthylenes	0.000092	0.000092	0.000000	0.000130	0.000130	0.000000	0.000092	0.000092	0.000000
peak annual acenaphthenes/ acenaphthylenes	0.000005	0.000005	0.000000	0.000005	0.000005	0.000000	0.000005	0.000006	0.000000
peak 1-hour anthracenes/ phenanthrenes and substitutes	0.000300	0.000300	0.000000	0.000299	0.000299	0.000000	0.000473	0.000473	0.000000
peak annual anthracenes/ phenanthrenes and substitutes	0.000012	0.000014	0.000002	0.000012	0.000014	0.000002	0.000015	0.000016	0.000002
peak 1-hour naphthalene and substitutes	0.009786	0.009786	0.000000	0.005757	0.006347	0.000590	0.015438	0.015438	0.000000
peak annual naphthalene and substitutes	0.000238	0.000292	0.000053	0.000190	0.000260	0.000070	0.000311	0.000368	0.000056
peak 1-hour biphenyl	0.001193	0.001193	0.000000	0.001331	0.001331	0.000000	0.001293	0.001293	0.000000
peak annual biphenyl	0.000048	0.000048	0.000000	0.000052	0.000052	0.000000	0.000047	0.000047	0.000000

Table 1.8-16 Comparison of the Existing and Approved Case and Project Case Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Averaging Period and Parameter[a]	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Change Due to Project[b] [μg/m³]	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Change Due to Project[b] [μg/m³]
peak 1-hour pyrenes and substitutes	0.000044	0.000044	0.000000	0.001858	0.001859	0.000001
peak annual pyrenes and substitutes	0.000003	0.000003	0.000000	0.000079	0.000079	0.000001
peak 1-hour fluorenes/fluoranthenes and substitutes	0.000158	0.000158	0.000000	0.002170	0.002171	0.000001
peak annual fluorenes/fluoranthenes and substitutes	0.000008	0.000008	0.000000	0.000096	0.000097	0.000001
peak 1-hour acenaphthenes/ acenaphthylenes	0.000119	0.000120	0.000000	0.001344	0.001345	0.000001
peak annual acenaphthenes/ acenaphthylenes	0.000005	0.000005	0.000000	0.000059	0.000060	0.000000
peak 1-hour anthracenes/ phenanthrenes and substitutes	0.000190	0.000192	0.000002	0.007213	0.007216	0.000003
peak annual anthracenes/ phenanthrenes and substitutes	0.000011	0.000012	0.000001	0.000306	0.000308	0.000002
peak 1-hour naphthalene and substitutes	0.002529	0.002557	0.000028	0.235410	0.235520	0.000110
peak annual naphthalene and substitutes	0.000165	0.000193	0.000028	0.009841	0.009906	0.000065
peak 1-hour biphenyl	0.003563	0.003563	0.000000	0.007085	0.007085	0.000000
peak annual biphenyl	0.000081	0.000081	0.000000	0.000100	0.000100	0.000000

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

(b) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

Note: There are no Alberta Ambient Air Quality Objectives for PAH compounds.

Table 1.8-17 Comparison of the Existing and Approved Case and Project Case 1-Hour Trace Metal Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]
Peak 1-Hour [µg/m^3](a)									
aluminum	0.002499	0.002499	0.000000	0.004875	0.004875	0.000000	0.002747	0.002747	0.000000
antimony	0.000135	0.000135	0.000000	0.000165	0.000165	0.000000	0.000170	0.000170	0.000000
arsenic(c)	0.000062	0.000063	0.000000	0.000100	0.000100	0.000000	0.000080	0.000166	0.000085
barium	0.000888	0.000925	0.000037	0.001516	0.001518	0.000002	0.001094	0.003641	0.002547
beryllium	0.000004	0.000005	0.000000	0.000008	0.000008	0.000000	0.000005	0.000010	0.000005
cadmium	0.000412	0.000412	0.000000	0.000938	0.000938	0.000000	0.000486	0.000920	0.000434
chromium(c)	0.001322	0.001322	0.000000	0.002457	0.002458	0.000001	0.001437	0.001501	0.000064
cobalt	0.000197	0.000197	0.000000	0.000264	0.000265	0.000000	0.000246	0.000246	0.000000
copper	0.000264	0.000266	0.000002	0.000486	0.000486	0.000000	0.000325	0.000705	0.000380
lead(c)	0.000241	0.000243	0.000001	0.000452	0.000452	0.000000	0.000282	0.000416	0.000134
manganese(c)	0.000479	0.000479	0.000000	0.000940	0.000940	0.000000	0.000542	0.000559	0.000017
mercury	0.000044	0.000054	0.000011	0.000078	0.000078	0.000000	0.000056	0.000215	0.000160
molybdenum	0.000359	0.000361	0.000003	0.000670	0.000671	0.000001	0.000433	0.000911	0.000478
nickel(c)	0.002744	0.002749	0.000005	0.004573	0.004574	0.000001	0.003769	0.003776	0.000007
selenium	0.000536	0.000536	0.000000	0.000869	0.000869	0.000000	0.000576	0.000576	0.000000
silver	0.000061	0.000061	0.000000	0.000137	0.000137	0.000000	0.000068	0.000068	0.000000
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000149	0.000149	0.000000	0.000255	0.000255	0.000000	0.000146	0.000146	0.000000
vanadium	0.005206	0.005214	0.000007	0.003878	0.003879	0.000001	0.007274	0.007275	0.000001
zinc	0.008948	0.009019	0.000071	0.018217	0.018231	0.000014	0.012093	0.024017	0.011924

Table 1.8-17 Comparison of the Existing and Approved Case and Project Case 1-Hour Trace Metal Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Change Due to Project[b] [μg/m³]	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Change Due to Project[b] [μg/m³]	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Change Due to Project[b] [μg/m³]
Peak 1-Hour [μg/m³][a]									
aluminum	0.002792	0.002792	0.000000	0.003810	0.003810	0.000000	0.002790	0.002790	0.000000
antimony	0.000136	0.000136	0.000000	0.000167	0.000167	0.000000	0.000144	0.000144	0.000000
arsenic[c]	0.000081	0.000083	0.000001	0.000088	0.000089	0.000001	0.000126	0.000126	0.000000
barium	0.001706	0.001737	0.000031	0.001161	0.001545	0.000384	0.002657	0.002659	0.000002
beryllium	0.000005	0.000006	0.000001	0.000006	0.000006	0.000000	0.000007	0.000007	0.000000
cadmium	0.000467	0.000475	0.000008	0.000639	0.000639	0.000000	0.000664	0.000665	0.000000
chromium[c]	0.001381	0.001531	0.000150	0.001896	0.001897	0.000001	0.001399	0.001513	0.000115
cobalt	0.000224	0.000224	0.000000	0.000254	0.000254	0.000000	0.000233	0.000234	0.000000
copper	0.000347	0.000353	0.000006	0.000375	0.000376	0.000000	0.000515	0.000515	0.000000
lead[c]	0.000224	0.000268	0.000044	0.000345	0.000345	0.000000	0.000307	0.000307	0.000000
manganese[c]	0.000501	0.000542	0.000041	0.000719	0.000719	0.000000	0.000511	0.000542	0.000031
mercury	0.000100	0.000102	0.000002	0.000056	0.000091	0.000035	0.000157	0.000157	0.000000
molybdenum	0.000444	0.000466	0.000022	0.000515	0.000515	0.000001	0.000664	0.000665	0.000000
nickel[c]	0.003633	0.003642	0.000010	0.003960	0.003966	0.000007	0.003751	0.003758	0.000006
selenium	0.000563	0.000563	0.000000	0.000660	0.000660	0.000000	0.000553	0.000553	0.000000
silver	0.000062	0.000062	0.000000	0.000097	0.000097	0.000000	0.000065	0.000065	0.000000
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000148	0.000148	0.000000	0.000194	0.000194	0.000000	0.000152	0.000152	0.000000
vanadium	0.005434	0.005435	0.000001	0.005294	0.005294	0.000000	0.005610	0.005612	0.000001
zinc	0.011797	0.013086	0.001289	0.014473	0.014487	0.000014	0.017511	0.017523	0.000012

Table 1.8-17 Comparison of the Existing and Approved Case and Project Case 1-Hour Trace Metal Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project[b] [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Change Due to Project[b] [µg/m³]
Peak 1-Hour [µg/m³][a]						
aluminum	0.002613	0.002613	0.000000	0.002913	0.002913	0.000000
antimony	0.000132	0.000132	0.000000	0.000171	0.000171	0.000000
arsenic[c]	0.000065	0.000065	0.000001	0.000965	0.002638	0.001673
barium	0.001090	0.001200	0.000110	0.021227	0.058028	0.036801
beryllium	0.000005	0.000005	0.000000	0.000058	0.000158	0.000100
cadmium	0.000364	0.000364	0.000000	0.005308	0.014519	0.009211
chromium[c]	0.001455	0.001455	0.000000	0.006754	0.018467	0.011713
cobalt	0.000185	0.000186	0.000000	0.000405	0.001110	0.000705
copper	0.000260	0.000262	0.000002	0.004101	0.011213	0.007112
lead[c]	0.000232	0.000234	0.000001	0.002412	0.006597	0.004184
manganese[c]	0.000556	0.000556	0.000000	0.001833	0.005014	0.003181
mercury	0.000064	0.000071	0.000007	0.001254	0.003429	0.002175
molybdenum	0.000368	0.000368	0.000000	0.005307	0.014507	0.009200
nickel[c]	0.002908	0.002914	0.000005	0.010131	0.027795	0.017664
selenium	0.000778	0.000778	0.000000	0.000682	0.000682	0.000000
silver	0.000064	0.000064	0.000000	0.000077	0.000077	0.000000
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000181	0.000181	0.000000	0.000159	0.000159	0.000000
vanadium	0.004645	0.004645	0.000000	0.011096	0.030648	0.019552
zinc	0.008609	0.008685	0.000075	0.139910	0.382480	0.242570

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

[b] Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

[c] There are no 1-hour AAAQO for metal compounds except for arsenic (0.1 µg/m³), chromium (1 µg/m³), lead (1.5 µg/m³), manganese (2 µg/m³) and nickel (6 µg/m³).

Table 1.8-18 Comparison of the Existing and Approved Case and Project Case Annual Trace Metal Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]
Peak Annual Average [µg/m^3](a)									
aluminum	0.000065	0.000065	0.000000	0.000095	0.000095	0.000000	0.000068	0.000068	0.000000
antimony	0.000002	0.000002	0.000000	0.000003	0.000003	0.000000	0.000002	0.000002	0.000000
arsenic(c)	0.000003	0.000003	0.000001	0.000004	0.000004	0.000000	0.000004	0.000008	0.000004
barium	0.000045	0.000057	0.000012	0.000059	0.000068	0.000009	0.000070	0.000157	0.000086
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
cadmium	0.000019	0.000022	0.000003	0.000027	0.000029	0.000002	0.000026	0.000048	0.000022
chromium	0.000039	0.000043	0.000004	0.000055	0.000058	0.000003	0.000048	0.000076	0.000027
cobalt	0.000005	0.000006	0.000000	0.000008	0.000008	0.000000	0.000007	0.000008	0.000002
copper	0.000012	0.000014	0.000002	0.000017	0.000018	0.000002	0.000017	0.000034	0.000017
lead	0.000009	0.000011	0.000001	0.000013	0.000014	0.000001	0.000013	0.000023	0.000010
manganese(c)	0.000015	0.000016	0.000001	0.000022	0.000022	0.000001	0.000018	0.000025	0.000007
mercury	0.000002	0.000003	0.000001	0.000003	0.000004	0.000001	0.000004	0.000009	0.000005
molybdenum	0.000015	0.000018	0.000003	0.000020	0.000022	0.000002	0.000021	0.000043	0.000022
nickel(c)	0.000106	0.000111	0.000006	0.000145	0.000149	0.000004	0.000138	0.000179	0.000041
selenium	0.000011	0.000011	0.000000	0.000016	0.000016	0.000000	0.000012	0.000012	0.000000
silver	0.000002	0.000002	0.000000	0.000003	0.000003	0.000000	0.000002	0.000002	0.000000
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000000	0.000005	0.000005	0.000000	0.000003	0.000003	0.000000
vanadium	0.000114	0.000120	0.000006	0.000129	0.000133	0.000005	0.000174	0.000219	0.000045
zinc	0.000408	0.000484	0.000076	0.000547	0.000604	0.000057	0.000578	0.001146	0.000568

Table 1.8-18 Comparison of the Existing and Approved Case and Project Case Annual Trace Metal Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Change Due to Project(b) [µg/m^3]
Peak Annual Average [µg/m^3](a)									
aluminum	0.000068	0.000068	0.000000	0.000083	0.000083	0.000000	0.000069	0.000069	0.000000
antimony	0.000002	0.000002	0.000000	0.000003	0.000003	0.000000	0.000002	0.000002	0.000000
arsenic(c)	0.000005	0.000006	0.000001	0.000004	0.000005	0.000002	0.000005	0.000006	0.000001
barium	0.000085	0.000110	0.000025	0.000058	0.000094	0.000036	0.000092	0.000120	0.000028
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
cadmium	0.000029	0.000036	0.000006	0.000024	0.000033	0.000009	0.000031	0.000039	0.000007
chromium	0.000053	0.000061	0.000008	0.000051	0.000062	0.000011	0.000056	0.000065	0.000009
cobalt	0.000007	0.000007	0.000000	0.000007	0.000008	0.000001	0.000007	0.000007	0.000001
copper	0.000020	0.000025	0.000005	0.000016	0.000023	0.000007	0.000022	0.000027	0.000005
lead	0.000014	0.000017	0.000003	0.000012	0.000016	0.000004	0.000015	0.000018	0.000003
manganese(c)	0.000019	0.000021	0.000002	0.000019	0.000023	0.000003	0.000020	0.000022	0.000002
mercury	0.000005	0.000006	0.000001	0.000003	0.000005	0.000002	0.000005	0.000007	0.000002
molybdenum	0.000025	0.000031	0.000006	0.000019	0.000028	0.000009	0.000027	0.000034	0.000007
nickel(c)	0.000137	0.000149	0.000012	0.000136	0.000153	0.000017	0.000142	0.000156	0.000013
selenium	0.000012	0.000012	0.000000	0.000014	0.000014	0.000000	0.000012	0.000012	0.000000
silver	0.000002	0.000002	0.000000	0.000003	0.000003	0.000000	0.000002	0.000002	0.000000
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000000	0.000004	0.000004	0.000000	0.000003	0.000003	0.000000
vanadium	0.000156	0.000169	0.000013	0.000135	0.000154	0.000019	0.000162	0.000177	0.000015
zinc	0.000672	0.000838	0.000166	0.000522	0.000760	0.000238	0.000724	0.000910	0.000185

Table 1.8-18 Comparison of the Existing and Approved Case and Project Case Annual Trace Metal Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [μg/m^3]	Project Case [μg/m^3]	Change Due to Project(b) [μg/m^3]	Existing and Approved Case [μg/m^3]	Project Case [μg/m^3]	Change Due to Project(b) [μg/m^3]
Peak Annual Average [μg/m^3](a)						
aluminum	0.000064	0.000064	0.000000	0.000077	0.000077	0.000000
antimony	0.000002	0.000002	0.000000	0.000002	0.000002	0.000000
arsenic(c)	0.000003	0.000003	0.000001	0.000021	0.000035	0.000014
barium	0.000047	0.000059	0.000013	0.000453	0.000751	0.000298
beryllium	0.000000	0.000000	0.000000	0.000001	0.000002	0.000001
cadmium	0.000019	0.000023	0.000003	0.000122	0.000196	0.000075
chromium	0.000039	0.000043	0.000004	0.000172	0.000268	0.000096
cobalt	0.000006	0.000006	0.000000	0.000014	0.000020	0.000006
copper	0.000012	0.000015	0.000002	0.000091	0.000149	0.000058
lead	0.000010	0.000011	0.000001	0.000056	0.000090	0.000034
manganese(c)	0.000015	0.000016	0.000001	0.000052	0.000078	0.000026
mercury	0.000003	0.000003	0.000001	0.000027	0.000044	0.000018
molybdenum	0.000015	0.000018	0.000003	0.000117	0.000192	0.000075
nickel(c)	0.000107	0.000113	0.000006	0.000318	0.000458	0.000140
selenium	0.000011	0.000011	0.000000	0.000014	0.000017	0.000002
silver	0.000002	0.000002	0.000000	0.000002	0.000002	0.000000
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000000	0.000004	0.000004	0.000000
vanadium	0.000117	0.000123	0.000007	0.000351	0.000496	0.000144
zinc	0.000413	0.000499	0.000085	0.003107	0.005076	0.001970

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

(b) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

(c) There are no annual AAAQO for metal compounds except for arsenic (0.01 μg/m^3), manganese (0.2 μg/m^3) and nickel (0.05 μg/m^3).

1.8.3.2 Transboundary Effects

There are no EAC or Project Case predicted concentrations above the respective AAAQOs or other applicable criteria at La Loche, Saskatchewan. The predictions at La Loche, Saskatchewan are presented with the selected receptors in Appendix 3-III.

1.8.3.3 Scientific Uncertainty

A discussion of the scientific uncertainty associated with the modelling is presented in Appendix 3-II, Section 2.3.10.

1.8.4 Key Question AQPC-2: What Effects Could the Project and the Existing and Approved Developments Have on the Deposition of Acid-Forming Compounds in the Region?

1.8.4.1 Impact Analysis

The initial step in evaluating the effects of the Project on the deposition of acid-forming compounds is a review of the regional emissions of SO_2 and NO_X. Table 1.8-19 shows that in the RSA, the SO_2 and NO_X emission rates in the Project Case will increase by 11.5% and 36.2%, respectively, compared with the EAC. In the modelling domain, the Project will result in increases of 0.5% and 1.9% in the Existing and Approved emissions of SO_2 and NO_X, respectively.

Table 1.8-19 Comparison of the Existing and Approved Case and Project Case Acid Precursor Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Change Due to Project[(a)] [%]
SO_2 emissions [t/cd]	10.81	12.06	11.5
NO_X emissions [t/d]	26.52	36.14	36.2

[(a)] Represents change between EAC and Project Case.

Although the changes in regional emissions give some indication of the impacts associated with the Project, it is necessary to run a dispersion model to quantify the effect that these emissions may have on the deposition of acid-forming compounds in the region. The modelling includes background PAI values determined by AENV using the Regional Lagrangian Acid Deposition Model (RELAD) model (Cheng 2001, 2005), as discussed in Appendix 3-II, Section 2.3.8. The Project Case PAI predictions are detailed in Appendix 3-III.

Table 1.8-20 compares the EAC and Project Case predicted maximum PAI concentrations within the RSA and LSA, excluding the developed areas. The emissions from the Project are predicted to increase the maximum PAI concentration in the RSA by approximately 38%, excluding developed areas. The emissions also result in increases in the areas in the RSA predicted to experience deposition values in excess of 0.17, 0.25, 0.50 and 1.00 keq/ha/yr.

Table 1.8-20 Comparison of the Existing and Approved Case and Project Case Potential Acid Input Predictions

Descriptions	Existing and Approved Case[(a)]	Project Case[(a)]	Change Due to Project[(b)]
Local Study Area			
maximum PAI [keq/ha/yr]	0.42	0.68	0.26
area >0.17 keq/ha/yr [ha]	21,521	43,491	21,970
area >0.25 keq/ha/yr [ha]	1,396	3,095	1,699
area >0.5 keq/ha/yr [ha]	0	31	31
area >1.0 keq/ha/yr [ha]	0	0	0
Regional Study Area			
maximum PAI [keq/ha/yr]	0.42	0.68	0.26
area >0.17 keq/ha/yr [ha]	101,721	148,544	46,823
area >0.25 keq/ha/yr [ha]	1,396	3,103	1,707
area >0.5 keq/ha/yr [ha]	0	31	31
area >1.0 keq/ha/yr [ha]	0	0	0

(a) Excludes predictions within developed areas, which include the Project plant sites.

(b) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

The CASA framework for managing acid deposition in Alberta considers management units represented by grid cells that are 1° by 1° in size. Table 1.8-21 presents a comparison of the EAC and Project Case predicted PAI concentrations for the twenty-five 1° by 1° grid cells that fall within the air modelling domain for the Project. The Project is located in grid cell 56º by 111º. The PAI level within cell 56º by 111º is expected to increase by 0.004 keq/ha/yr. Of the 25 grid cells listed, two were predicted to have PAI values in excess of the 0.25 keq/ha/yr critical load for sensitive ecosystems in both the EAC and Project Case. These two cells are located about 150 km NNW of the Project.

Table 1.8-21 Comparison of the Existing and Approved Case and Project Case Potential Acid Input Predictions for 1° by 1° Grid Cells

Grid Cell Centre(a)	Existing and Approved Case [keq/ha/yr]	Project Case [keq/ha/yr]	Change Due to Project [keq/ha/yr](b)
58°×113°	0.062	0.062	0.000
58°×112°	0.076	0.076	0.000
58°×111°	0.110	0.110	0.000
58°×110°	0.070	0.070	0.000
58°×109°	0.056	0.056	0.000
57°×113°	0.091	0.091	0.000
57°×112°	0.330	0.330	0.000
57°×111°	0.341	0.341	0.000
57°×110°	0.118	0.118	0.000
57°×109°	0.086	0.086	0.000
56°×113°	0.107	0.107	0.000
56°×112°	0.112	0.113	0.001
56°×111°(c)	0.161	0.165	0.004
56°×110°	0.127	0.130	0.003
56°×109°	0.101	0.102	0.001
55º×113º	0.132	0.132	0.000
55º×112º	0.128	0.129	0.001
55º×111º	0.158	0.160	0.002
55º×110º	0.153	0.155	0.002
55º×109º	0.102	0.103	0.001
54º×113º	0.167	0.167	0.000
54º×112º	0.151	0.151	0.000
54º×111º	0.102	0.102	0.000
54º×110º	0.097	0.098	0.000
54º×109º	0.085	0.086	0.000

(a) The 1° by 1° grid cells are centred on the listed latitude and longitude.

(b) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between EAC and Project Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed concentrations.

(c) The Project is located in cell 56º×111º.

The Project Case acid-precursor emissions are expected to increase the maximum predicted PAI levels and the areas predicted to experience PAI levels above the 0.17 and 0.25 keq/ha/yr thresholds. Several of the 1° by 1° grid cells are also expected to show an increase in the maximum predicted PAI levels; however, there are no new exceedances of the 0.17 keq/ha/yr threshold from the EAC to the Project Case.

1.8.4.2 Scientific Uncertainty

A discussion of the scientific uncertainty associated with the modelling is presented in Appendix 3-II, Section 2.3.10.

1.8.5 Key Question AQPC-3: What Effects Could the Project and the Existing and Approved Developments Have on Concentrations of Ground-Level Ozone in the Region?

1.8.5.1 Impact Analysis

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. This ground-level ozone can be the result of several factors, including photochemical ozone formation, mixing from the upper troposphere, stratospheric intrusion of ozone from the upper atmosphere and long-range transport. Of these, the Project has potential to affect photochemical ozone formation through the release of ozone precursor emissions (i.e., NO_X and VOCs).

Photochemical ozone formation is one of the key ingredients of urban smog. Photochemical ozone forms when large volumes of oxides of nitrogen (NO_X) and VOCs are present during the right meteorological conditions. This type of ozone formation occurs during the daylight hours in the summer months when hot, sunny, stagnant conditions favour the necessary chemical reactions, as shown in the following equation:

$$VOC + sunlight + NO_X \rightarrow O_3$$

One of the concerns regarding industrial and urban activities is that increased emissions of NO_X and VOCs could lead to increases in ground-level ozone concentrations.

Certain factors and conditions can cause ground-level ozone levels to be depleted. Ozone destruction dominates under the following conditions (AENV 2001):

- high nitric oxide (NO) emissions;
- low solar radiation during the night;
- limited VOCs near NO_X sources; and
- limited mixing in a NO_X rich environment.

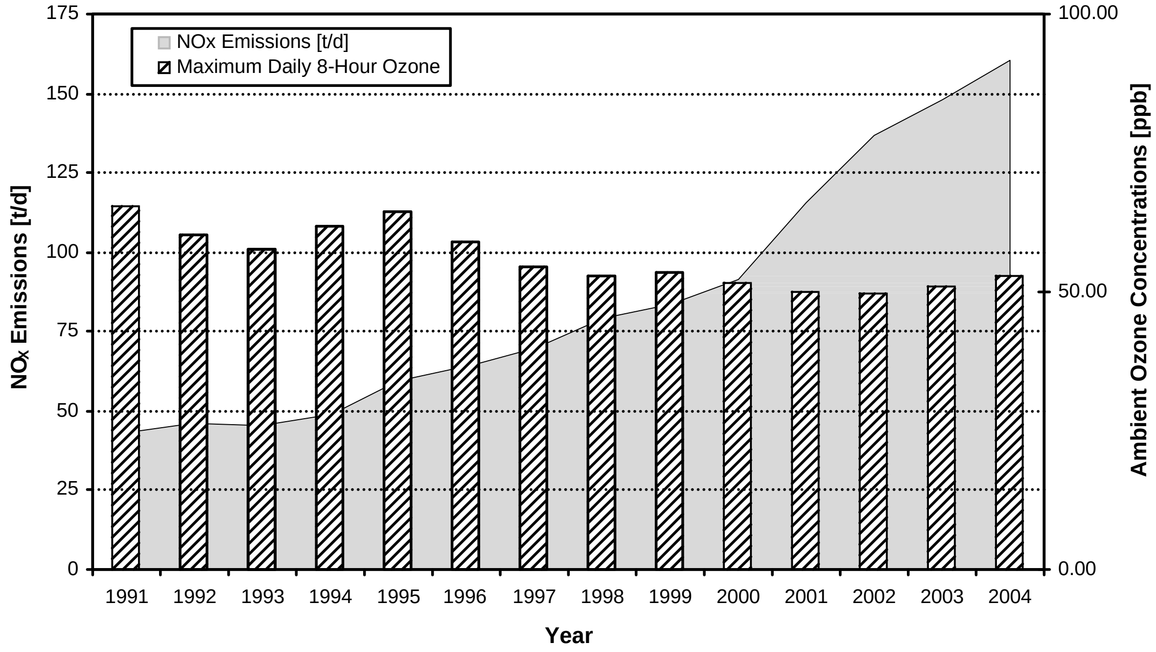
Ozone destruction by reaction with NO is illustrated in the following equation:

$$O_3 + NO \rightarrow O_2 + NO_2$$

Since NO_X emissions can cause ozone destruction, regions that experience relatively high background ozone concentrations may experience a decline in average ozone concentrations with an increase in anthropogenic (man-made) emissions of NO_X. This was recognized by the authors responsible for developing the CWS for ozone (CWSDC 1999).

Available information suggests that an increase in NO_X emissions could increase or decrease ozone concentrations. Fort McMurray is an example of where increasing NO_X emissions have appeared to lead to a decrease in ozone concentrations. Figure 1.8-1 presents a comparison of monitored maximum 8-hour ozone concentrations in Fort McMurray and estimated NO_X emission rates in the Oil Sands Region (CEMA 2003) from 1991 through 2004. The figure indicates that the 8-hour ozone concentrations in Fort McMurray have been generally decreasing since 1991, while the NO_X emissions in the region of the community have been increasing over the same time period. These opposing trends indicate that increasing regional NO_X emissions may result in decreased ground-level ozone concentrations.

Since there are many factors that can affect ground-level ozone concentrations, there is no simple explanation for the formation/destruction of ozone in the region. One approach to determining the possible effect of the Project emissions of ozone precursor chemicals (i.e., NO_X and VOCs) on regional ozone concentrations is to evaluate the change in NO_X and VOC emission rates. Table 1.8-22 provides a comparison of the EAC and Project Case emissions of ozone precursor chemicals (i.e., NO_X and VOCs) in the RSA. In the RSA, the emissions from the Project would result in a 36.2% and 46.1% increase in the NO_X and VOC emission rates from the EAC releases in the region, respectively. However, in the modelling domain, the emissions from the Project would result in a 1.9% and 0.1% increase in the NO_X and VOC emission rates from the EAC releases in the region, respectively.



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

COMPARISON OF FORT McMURRAY OZONE CONCENTRATIONS AND REGIONAL OXIDES OF NITROGEN EMISSIONS

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000		FILE No.	Compare–Fort Mc	
DESIGN	MS	29/01/08	SCALE	AS SHOWN	REV. 0
CADD	MM	01/04/08	**FIGURE: 1.8-1**		
CHECK	MS	01/04/08			
REVIEW	IGG	07/04/08			

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8000\8020\Fig 1.8-1 Comparison of Fort McMurray OZone Concentrations and Regional.dwg Apr 10, 2008 - 11:24am

Table 1.8-22 Comparison of the Existing and Approved Case and Project Case Ozone Precursor Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Change Due to Project [%][(a)]
NO_X emissions [t/d]	26.52	36.14	36.2
VOC emissions [t/d]	1.29	1.88	46.1
total ozone precursor emissions [t/d][(b)]	27.81	38.02	36.7

(a) Represents the change between EAC and Project Case.

(b) Total ozone precursor emissions are the sum of NO_X and VOC emissions.

The changes in peak ozone concentrations in the region due to emissions from the Project can be estimated by applying a relationship developed by the Ozone Modelling Working Group (OMWG) sanctioned by and accountable to WBEA (Earth Tech Inc. and Conor Pacific 1998). The OMWG was formed to enhance the understanding of ground-level ozone through modelling of current precursor emissions and secondary ozone production. One of the preliminary findings of this work, which has been cited in recent applications (Shell 2005; Suncor 2005), indicated that a near doubling of anthropogenic (man-made) emissions of NO_X and VOC could result in an increase in the peak ozone concentrations by as much as 30 ppb on hot, stagnant summer days. Therefore, the 36.7% increase in ozone precursor emissions in the RSA from the Project could increase peak ozone concentrations by approximately 11 ppb in the RSA. In the modelling domain, the 0.9% increase in ozone precursor emissions from the Project could increase peak ozone concentrations by approximately 0.3 ppb.

1.8.5.2 Scientific Uncertainty

There is a great deal of uncertainty associated with the sources of ozone in the region, the chemical reactions associated with ozone production and the possible transport of ozone over long distances. In response to these uncertainties, Environment Canada and the WBEA are continuing their investigations of the ozone issue in the region including enhanced monitoring and modelling efforts.

1.8.6 Key Question AQPC-4: Will Emissions From the Project be in Compliance With Relevant Provincial and Federal Emission Guidelines?

1.8.6.1 Impact Analysis

The Project has incorporated compliance with the following relevant provincial and federal emissions guidelines in the design of the process and selection of equipment:

- the new steam generators and heater at the Project will be in compliance with CCME *National Emission Guidelines for Commercial/Industrial Boilers and Heaters* (CCME 1998), where applicable;
- when produced gas and natural gas are used to fire steam generators, the ERCB sulphur recovery guidelines (EUB ID 2001-3) will be met;
- flaring will be minimized for the Project (e.g., upset/emergency conditions, start-up and commissioning); and
- above-ground storage tanks will conform to *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Above Ground Storage Tanks* (CCME 1995).

Since the Project will meet emission guidelines, an impact assessment is not required.

1.8.7 Key Question AQPC-5: What Effects Could the Project and the Existing and Approved Developments Have on Odours at the Selected Receptors?

1.8.7.1 Impact Analysis

The initial step in evaluating the impact of the Project on odour levels at the selected receptors is a review of the emissions of the primary odorous compounds: VOC and TRS compounds. Table 1.8-23 shows that in the RSA, the VOC and TRS emission rates from Project Case will increase by 46.1% and 51.9%, respectively. In the modelling domain, the VOC and TRS emission rates from Project Case will increase by 0.1% and 0.6%, respectively.

Table 1.8-23 Comparison of the Existing and Approved Case and Project Case Odorous Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Change Due to Project[a] [%]
VOC emissions [t/d]	1.29	1.88	46.1
TRS emissions [t/d]	0.08	0.13	51.9

[a] Represents change between EAC and Project Case.

The effect of the Project emissions, in combination with EAC emissions in the modelling domain, on the odours at the selected receptors was evaluated by predicting ground-level concentrations of odorous compounds with the CALPUFF model. The primary sources of odorous emissions from the Project are plant fugitive emissions.

The effect of the Project emissions, in combination with EAC emissions, on odours at the selected receptors was evaluated through the use of accepted odour threshold values. Tables 1.8-24 and 1.8-25 summarize the odour threshold values used in this assessment.

Table 1.8-24 Odour Threshold Values for Total Reduced Sulphur Compounds

Compound	Odour Thresholds [µg/m³]	
	Typical[a]	Range
sulphides		
hydrogen sulphide	14.1	0.1 – 2,000
carbon disulphide	749.2	24.3 – 23,100
diallyl sulphide	8.6	0.5 – 149.1
diethyl sulphide	17.7	17.7 – 17.7
dimethyl disulphide	5.9	0.1 – 346.5
dimethyl sulphide	2.8	0.91 – 55.4
mercaptans		
amyl mercaptan	0.4	0.1 – 1.8
butyl mercaptan	3.7	1.5 – 18,000
ethyl mercaptan	2.8	0.003 – 190
methyl mercaptan	0.6	0 – 1,100
propyl mercaptan	3.9	0.2 – 74.6
thiophenes		
thiophene	233.7	2.6 – 21,000
1,3-dimethyl thiophene	233.7	2.6 – 21,000
2,5-dimethyl thiophene	233.7	2.6 – 21,000
2-methyl thiophene	233.7	2.6 – 21,000
3-methyl thiophene	233.7	2.6 – 21,000

[a] The typical threshold value was selected as being the most representative number from the available literature (AIHA 1989; Amoore and Hautala 1983; ASHRAE 1981; AWMA 2000; Fazzalari 1978; National Institutes of Health 2004; Ruth 1986; U.S. EPA 1992; van Gemert and Nettenbreijer 1977). In many cases, the lowest odour threshold values from literature have not been supported by repeat tests or follow-up studies.

Table 1.8-25 Odour Threshold Values for Volatile Organic Compounds

Compound	Odour Thresholds [µg/m³]	
	Typical[(a)]	Range
1,3-butadiene	13,000.0	1,000 – 169,000
acrolein	4,100.0	50 – 37,500
aldehydes		
acetaldehyde	4,647.6	12 – 1,800,000
3-methylbutanal	0.6	0.6 – 0.6
butanal	441.6	13 – 15,000
crotonaldehyde	320.3	180 – 570
decanal	30.8	0.3 – 3,800
dodecanal	16.4	16 – 16
heptanal	238.7	6 – 9,500
hexanal	28.0	20 – 39
isobutyraldehyde	251.1	140 – 450
nonanal	22.6	0.3 – 1,700
octanal	141.4	4 – 5,000
propanal	2,190.9	20 – 240,000
undecanal	18.7	0.5 – 700
benzene	35,707.1	2,500 – 510,000
C_2-C_8 aliphatics		
2-ethyl-1-hexanol	543.4	399 – 740
2-methylpentane	288.6	289 – 289
acetylene	812,403.8	240,000 – 2,750,000
butane	6,000,000.0	3,000,000 – 12,000,000
cis-2-butene	28,500.0	28,500 – 28,500
cyclohexane	69,713.7	1,800 – 2,700,000
cyclooctane	3,600.0	3,600 – 3,600
ethane	149,916,643.5	25,000,000 – 899,000,000
ethene	148,324.0	20,000 – 1,100,000
ethylene dibromide	76,800.0	76,800 – 76,800
heptane	607,947.4	165,000 – 2,240,000
hexane	448,609.0	230,000 – 875,000
isobutane	1,370,000.0	1,370,000 – 1,370,000
methylcyclohexane	2,000,000.0	2,000,000 – 2,000,000
octane	710,000.0	71,000 – 1,100,000
octyne	2,000.0	2,000 – 2,000
pentane	1,039,951.9	350,000 – 3,090,000
pentene	594.5	595 – 595
propane	28,142,494.6	22,000,000 – 36,000,000
propene	38,000.0	17,300 – 170,000
propylene oxide	111,246.2	24,000 – 515,655
trans-2-butene	2,700,000.0	2,700,000 – 2,700,000

Table 1.8-25 Odour Threshold Values for Volatile Organic Compounds (continued)

Compound	Odour Thresholds [µg/m³]	
	Typical[(a)]	Range
C_9-C_{16} aliphatics		
decane	11,300.0	11,300 – 11,300
dodecane	37,000.0	37,000 – 37,000
nonane	452,493.1	60,000 – 3,412,500
tridecane	42,000.0	42,000 – 42,000
undecane	92,747.0	23,000 – 374,000
C_6-C_8 aromatics		
acetophenone	170.3	10 – 2,900
benzaldehyde	1,529.7	180 – 13,000
ethylbenzene	18,654.8	400 – 870,000
styrene	4,147.3	20 – 860,000
toluene	4,582.6	80 – 262,500
(p+m)-xylene+other	1,500.0	1,500 - 1,500
o-xylene	23,600.0	800 – 23,600
xylene	100,000.0	0.2 – 1,370,000
C_9-C_{16} aromatics		
cumene	42.9	25 – 6,400
p-cymene	12.0	12 – 12
formaldehyde	19,899.7	33 – 12,000,000
ketones		
acetone	8,600.0	1,100 – 1,900,000
camphor	490.0	16 – 45,000
methyl ethyl ketone	5,800.0	750 – 250,000
methanol	1,057,355.2	4,300 – 260,000,000
phenol	650.9	19 – 22,420
trimethylbenzenes		
1,2,3-trimethylbenzene	643.5	32 – 12,870
1,2,4-trimethylbenzene	1,549.2	200 – 12,000
1,3,5-trimethylbenzene	1,549.2	200 – 12,000

[(a)] The typical threshold value was selected as being the most representative number from the available literature (AIHA 1989; Amoore and Hautala 1983; ASHRAE 1981; AWMA 2000; Fazzalari 1978; National Institutes of Health 2004; Ruth 1986; U.S. EPA 1992; van Gemert and Nettenbreijer 1977). In many cases, the lowest odour threshold values from literature have not been supported by repeat tests or follow-up studies.

Table 1.8-26 presents a comparison of the EAC and Project Case 1-hour odour predictions for the selected receptors. The results indicate that the Project emissions will increase the predicted 1-hour odour levels at the Maximum Property Boundary. At the Maximum Property Boundary, the Project is expected to increase the number of hours above the threshold by 86 hours or 1.0% of the time.

Table 1.8-26 Comparison of the Existing and Approved Case and Project Case 1-Hour Odour Predictions

Receptor	Existing and Approved Case[(a)]		Project Case[(a)]		Change Due to Project [%]
	Hours > Threshold	Fraction of Time [%]	Hours > Threshold	Fraction of Time [%]	
Conklin	0	0.0	0	0.0	0.0
Janvier/Chard (IR 194)	0	0.0	0	0.0	0.0
Winefred Lake (IR 194B)	0	0.0	0	0.0	0.0
Hunter/Trapper A	0	0.0	0	0.0	0.0
Hunter/Trapper B	0	0.0	0	0.0	0.0
Operator's Residence	0	0.0	0	0.0	0.0
Christina Lake Lodge	0	0.0	0	0.0	0.0
Maximum Property Boundary	14	0.2	100	1.1	1.0

(a) Calculated on a yearly basis.

The CALPUFF model predictions are representative of concentrations averaged over a 1-hour period; however, the actual ground-level concentrations will fluctuate within the averaging period. The ability to detect odours is usually related to the high “peak” concentrations during each hour. To address these fluctuations, a “peak” concentration was determined by applying a multiplication factor to the CALPUFF model estimates. Authors such as Turner (1969), Hanna et al. (1982), and Pasquill and Smith (1983) have proposed various factors suitable to convert 1-hour average predictions to peak concentrations. A factor of 10 is most suitable when near point sources and a factor of two is most suitable when receptors are 2 to 5 km away from the emission sources.

Table 1.8-27 presents a comparison of the EAC and Project Case peak odour predictions at the selected receptors. The results indicate that if a peak factor of 2 is applied (this factor is most applicable 2 to 5 km away), there would be no odour events. Due to the proximity to the Project, a peak factor of 10 was applied to the Maximum Property Boundary. An increase in odour events (i.e., peak odour concentrations exceeding the threshold) of 1,151 hours is predicted at the Maximum Property Boundary. This is equivalent to 13.1% of the time.

Table 1.8-27 Comparison of the Existing and Approved Case and Project Case Peak Odour Predictions

Receptor	Existing and Approved Case[a]		Project Case[a]		Change Due to Project [%]
	Hours > Threshold[b]	Fraction of Time [%] [b]	Hours > Threshold[b]	Fraction of Time [%] [b]	
Conklin	0	0.0	0	0.0	0.0
Janvier/Chard (IR 194)	0	0.0	0	0.0	0.0
Winefred Lake (IR 194B)	0	0.0	0	0.0	0.0
Hunter/Trapper A	0	0.0	0	0.0	0.0
Hunter/Trapper B	0	0.0	0	0.0	0.0
Operator's Residence	0	0.0	0	0.0	0.0
Christina Lake Lodge	0	0.0	0	0.0	0.0
Maximum Property Boundary[c]	816	9.3	1,967	22.5	13.1

[a] Calculated on a yearly basis.

[b] Values are based on a peaking factor of 2, which is within 2 to 5 km from the source.

[c] Values are based on a peaking factor of 10.

Based on the odour predictions, odours will not be detected at any of the selected receptors, except the Maximum Property Boundary. This evaluation was based on comparing the peak instantaneous concentrations to accepted odour thresholds.

Odour was also assessed at La Loche, Saskatchewan and there are no predicted 1-hour concentrations above the threshold.

1.8.8 Key Question AQPC-6: What is the Contribution of the Project to Greenhouse Gas Emissions?

1.8.8.1 Impact Analysis

The first step in completing the impact analysis for this key question is to characterize the Greenhouse Gas (GHG) releases from the Project. Emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and total greenhouse gases (expressed as equivalent carbon dioxide (CO_2E), which includes the higher greenhouse potential of CH_4 and N_2O) were estimated for the Project during construction, operation and reclamation activities.

The emissions from Project operations include CO_2, CH_4 and N_2O resulting from natural gas and produced gas combustion as well as CH_4 from plant fugitives. Greenhouse Gas emissions from natural gas and produced gas combustion were calculated based on emission factors from United States Environmental Protection Agency (U.S. EPA) AP-42 Table 1.4-2 (U.S. EPA 1995). These emission factors are presented in Table 1.8-28. Project GHG emissions calculated by using these emission factors are presented in Table 1.8-29. Due to the uncertainty of the activity level for each year, annual and total GHG emissions from the Project are based on the maximum capacity of the Project. The GHG emissions are expected to be lower in reality since the Project is unlikely to operate at maximum capacity all the time. Methane emissions from plant fugitives are also included in total GHG emission calculations. The annual maximum GHG emissions from the Project are estimated to be 4,537 kilotonnes per year (kt/y) CO_2E. A sample calculation of GHG emission rates from the produced gas combustion is presented below.

$$\text{Maximum amount of produced gas combusted} = 6{,}867{,}043\frac{m^3}{d}$$

$$CO_2 = 6{,}867{,}043\frac{m^3}{d}\times 1{,}799\frac{g}{m^3}\times 365\frac{d}{y}\times\frac{kt}{10^9 g} = 4{,}509\frac{kt}{y}$$

$$CH_4 = 6{,}867{,}043\frac{m^3}{d}\times 0.034\frac{g}{m^3}\times 365\frac{d}{y}\times\frac{kt}{10^9 g} = 0.086\frac{kt}{y}$$

$$N_2O = 6{,}867{,}043\frac{m^3}{d}\times 0.033\frac{g}{m^3}\times 365\frac{d}{y}\times\frac{kt}{10^9 g} = 0.083\frac{kt}{y}$$

$$CO_2E = 4{,}509\frac{kt\,CO_2}{y} + 0.086\frac{kt\,CH_4}{y}\times 21 + 0.083\frac{kt\,N_2O}{y}\times 310 = 4{,}537\frac{kt}{y}$$

$$CO_2E = 4{,}537\frac{kt}{y}$$

Table 1.8-28 Greenhouse Gas Emissions Factors for Natural Gas and Produced Gas Combustion

Source	CO_2	CH_4	N_2O
natural gas based on HHV[(a)] of 1,020 Btu/scf [g/m³][(b)]	1,922	0.037	0.035
natural gas based on HHV of 1,004.32 Btu/scf [g/m³][(b)]	1,893	0.036	0.035
produced gas based on HHV of 954.67 Btu/scf [g/m³][(b)]	1,799	0.034	0.033
light-duty gasoline vehicles (non-catalytic controlled) [g/L][(c)]	2,360	0.46	0.028
light-duty gasoline trucks (non-catalytic controlled) [g/L][(c)]	2,360	0.56	0.028
heavy-duty gasoline vehicles (uncontrolled) [g/L][(c)]	2,360	0.49	0.084
light-duty diesel trucks (uncontrolled) [g/L][(c)]	2,730	0.085	0.16
heavy-duty diesel vehicles (uncontrolled) [g/L][(c)]	2,730	0.15	0.075
off-road gasoline vehicles [g/L][(c)]	2,360	2.7	0.050
off-road diesel vehicles [g/L][(c)]	2,730	0.15	1.1

(a) Higher Heating Value (HHV).

(b) Calculated – data taken from U.S. EPA AP-42 Table 1.4-2 (U.S. EPA 1995).

(c) National Inventory Report 1990–2005: Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2007).

The GHG emission estimates for the construction phase of the Project were based on the diesel and gasoline fuel consumption and the equipment profile used for the construction. Construction GHG emissions were calculated using the emission factors from the National Inventory Report 1990 – 2005 Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2007). Greenhouse Gas emission factors used in the calculations are presented in Table 1.8-28. The plant construction will be completed in two years for each Phase of the Project. The plant construction GHG emissions were calculated to be 65 kt CO_2E for each Phase of the Project as detailed in Table 1.8-29.

Greenhouse gas emissions from the construction during the operation phase were assumed to be 10% of the plant construction annual GHG emissions. This assumption is based on the expected activity level and the use of similar equipment during that time. Similarly, GHG emissions from the decommissioning and reclamation activities were assumed to be 50% of the plant construction annual GHG emissions.

Table 1.8-29 MEG Project Greenhouse Gas Emissions

Phase	Timeline			Emissions [kt/yr]				Overall CO_2E Emissions [kt]
	Start	End	Duration [yr]	CO_2	CH_4	N_2O	CO_2E[a]	
Plant Construction – Plant 3A	2010	2011	2	30	0.003	0.009	33	65
Plant Construction – Plant 3B	2012	2013	2	30	0.003	0.009	33	65
Operation – Plant 3A	2012	2036	25	2,256	0.057	0.041	2,270	56,748
Operation – Plant 3B	2014	2038	25	2,257	0.057	0.041	2,271	56,770
Decommissioning and reclamation – Plant 3A	2037	2042	5	15	0.001	0.005	16	82
Decommissioning and reclamation – Plant 3B	2039	2044	5	15	0.001	0.005	16	82
Total[b]	**n/a**	**n/a**	**34**	**n/a**	**n/a**	**n/a**	**n/a**	**113,811**

[a] Equivalent CO_2 emissions were calculated using global warming potentials of 1 for CO_2, 21 for CH_4 and 310 for N_2O.

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

n/a = Not applicable.

Table 1.8-30 provides a summary of provincial and national GHG emissions as reported in Canada. GHG emission contribution from the Project will amount to 1.8% of the projected 2015 Alberta emissions and 0.56% of the 2015 emissions projected for Canada.

Table 1.8-30 National and Provincial Greenhouse Gas Emissions

Reporting Year	Canadian Emissions [kt CO_2E/yr]		Alberta Emissions [kt CO_2E/yr]	
	Overall[a]	Fossil Fuel Industries[b]	Overall[a]	Fossil Fuel Industries[b]
1990	596,000	52,000	170,000	32,000
1995	646,000	54,000	198,000	34,000
1996	664,000	55,000	203,000	33,000
1997	677,000	51,000	206,000	31,000
1998	683,000	55,000	208,000	34,000
1999	695,000	66,000	215,000	43,000
2000	721,000	67,000	224,000	44,000
2001	714,000	68,000	225,000	45,000
2002	720,000	73,000	224,000	46,000
2003	745,000	74,000	232,000	45,000
2004	747,000	72,000	231,000	43,000
2005	747,000	73,000	233,000	44,000
2010 (projected)	764,000	121,231	233,000	83,892
2015 (projected)	813,000	133,213	254,000	95,310
2020 (projected)	845,000	135,140	264,000	97,884

[a] Data for the years 1990 through 2005 are from Environment Canada (2007). Data for the years 2010 through 2020 are from Natural Resources Canada (1999).

[b] Fossil Fuel Industries include petroleum production (upstream oil industry) refining industries, natural gas production and some conventional and unconventional oil production industries (some refining are included). Data for the years 1990 through 2005 are from Environment Canada (2007). Data for the years 2010 through 2020 are from the Upstream Oil and Gas industry in Natural Resources Canada (1999).

1.8.8.2 Approach to Managing Greenhouse Gases

MEG's corporate GHG emission reduction strategy focuses on reducing GHG emissions on a per unit of production basis. MEG is examining ways to improve overall efficiency of operations to enhance energy efficiency and reduce emissions from production, facility and field operations. The economics of emission reductions will be evaluated, along with the benefits of reducing GHG emissions. Amongst the opportunities being considered are emissions capture and sequestration technologies.

1.8.8.3 Greenhouse Gas Intensity Comparison

Greenhouse Gas intensities for other in-situ and SAGD projects are shown in Table 1.8-31. These intensities were taken from each development's Alberta *Environmental Protection and Enhancement Act* (EPEA) approval.

Table 1.8-31 Greenhouse Gas Intensities for Approved Oil Sands Developments

Project	EPEA Approval Number	GHG Intensity [kg CO_2E/bbl]
Imperial Oil Resources Limited Cold Lake Project	73534-00-04	85 to 95
EnCana FCCL Oil Sands Ltd. Christina Lake Thermal Project	48522-00-08	70 to 75
EnCana FCCL Oil Sands Ltd. Foster Creek In-Situ Project Phases 2 and 3	68492-00-07	70 to 110
Husky Energy Inc. Tucker Thermal Project	147753-00-00	70 to 75
Devon Canada Corporation. Jackfish SAGD Project	183875-00-00	65 to 70
BlackRock Ventures Inc. Orion Project	141258-00-00	100 to 105
ConocoPhillips Canada Surmont Commercial SAGD	48263-00-00	70 to 110
OPTI Canada Inc./Nexen Canada Ltd. Long Lake Project	137467-00-00	180 to 220

The MEG Project GHG intensity for the operations phase is 83 kg CO_2E/bbl. This intensity is based on the maximum GHG emissions from the Project and will be lower when the plants are not operating at maximum capacity. The calculated GHG intensity for the Project is in the range of those at other approved projects in the region.

1.9 PLANNED DEVELOPMENT CASE

1.9.1 Introduction

The PDC includes a review of the cumulative air quality effects that could result from the existing and approved developments, the Project and the planned (publicly disclosed) developments in the region. Since the PDC includes planned projects, none of which have received approval to operate and some of which have yet to apply for approval, the emissions used in the Planned Development Case represent levels that are speculative and are based on the information available as of October 2007.

1.9.2 Emissions

For the purposes of the PDC, planned developments are considered in addition to the Project and existing and approved developments in the region. Although most of these planned developments are only disclosed and have not yet been the subject of formal approval applications, they could result in additional environmental effects should they proceed. The oil sands developments included in the modelling domain for the PDC are summarized in Table 1.9-1.

The development details provided are based on publicly available information. Because these developments are in varying stages of planning, the following should be noted:

- there is uncertainty about whether these planned developments will proceed;
- technical information for the planned developments are variable and typically limited; and
- all of the planned developments must submit applications and undergo assessment to receive approval to proceed.

Table 1.9-1 Oil Sands Activities Included in the Planned Development Case

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
MEG Energy Corp.			
Christina Lake Regional Project – Pilot	existing/approved	—	—
Christina Lake Regional Project – Commercial (Phases 2 and 2B)	approved	—	—
Christina Lake Regional Project – Commercial (Phases 3A and 3B)	—	—	—
EnCana Corporation			
Christina Lake Thermal Project	existing/approved	14.49	SW
Foster Creek Pilot	existing/approved	67.03	S
Foster Creek Phases 1 and 2	existing/approved	67.59	S
Borealis SAGD Project	planned	166.04	N
Devon Canada Corporation			
Jackfish SAGD Project	approved	18.07	SSW

Table 1.9-1 Oil Sands Activities Included in the Planned Development Case (continued)

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
Jackfish SAGD Project Phase 2	planned	22.76	SW
Petrobank			
Whitesands Pilot Project	existing/approved	33.63	W
Canadian Natural Resources Limited			
Primrose North	approved	88.21	S
Burnt Lake Project	existing/approved	98.82	SSE
Primrose South	existing/approved	99.76	S
Primrose East In-Situ Oil Sands Project	approved	99.93	SSE
Wolf Lake	existing/approved	107.92	S
Horizon Oil Sands Project	approved	196.55	NNW
Horizon In-Situ Project	planned	196.98	NNW
Kirby In-Situ Oil Sands Project	planned	41.12	SSW
Statoil Canada Ltd.			
Kai Kos Dehseh SAGD Project	planned	49.00	WNW
ConocoPhillips Canada Resource Ltd.			
Surmont Commercial SAGD Project	approved	60.31	NNW
OPTI Canada Inc./Nexen Canada Ltd.			
Long Lake Pilot Project	existing/approved	83.29	N
Long Lake Commercial Project	approved	83.86	N
Long Lake South SAGD Project	planned	72.67	NNW
Connacher Oil and Gas Limited			
Great Divide Oil Sands Project	approved	85.41	NW
Algar Oil Sands Project	planned	79.68	NW
Petro-Canada Oil and Gas			
Meadow Creek In-Situ Project	approved	81.58	NNW
Meadow Creek Expansion SAGD Project	planned	91.42	NNW
MacKay River In-Situ Project	approved	169.44	NNW
MacKay River Expansion SAGD Project	planned	170.16	NNW
Dover SAGD Pilot and VAPEX Pilot	existing/approved	171.93	NNW
Lewis SAGD Project	planned	138.14	N
Japan Canada Oil Sands Limited			
Hangingstone In-Situ Pilot Project	existing/approved	92.97	NW
Hangingstone SAGD Project	planned	94.51	NW
Imperial Oil Resources Limited			
Cold Lake In-Situ Project	existing/approved	115.34	S
Imperial Oil Resources Ventures Limited			
Kearl Oil Sands Project	approved	194.28	N
Husky Energy Inc.			
Tucker Thermal Project	existing/approved	122.77	S
Sunrise Thermal Project	approved	176.63	N
Shell Canada Limited			
Orion EOR Project	approved	127.20	S
Jackpine Mine – Phase 1	approved	180.19	NNW
Jackpine Mine Expansion	planned	180.23	NNW
Pierre River Mine	planned	209.96	NNW
Parsons Creek Resources			

Table 1.9-1 Oil Sands Activities Included in the Planned Development Case (continued)

Oil Sands Development	Status	Location[(a)]	
		Distance [km]	Direction
North Parsons Creek Project	planned	138.93	NNW
Suncor Energy Inc.			
South Tailings Pond	existing/approved	139.57	NNW
Lease 86/17, Steepbank & Millennium Mines	existing/approved	148.98	NNW
Voyageur Upgrader	approved	153.08	NNW
Upgrader Complex	existing/approved	156.44	NNW
North Steepbank Extension Mine	approved	156.46	NNW
Millennium Coker Unit (MCU)	approved	156.61	NNW
Millennium Vacuum Unit (MVU)	existing/approved	156.93	NNW
Firebag Enhanced Thermal Solvent (ETS) Pilot Project	existing/approved	172.60	N
Firebag SAGD Project	existing/approved	174.92	N
Voyageur South Project	planned	153.96	NNW
Syncrude Canada Ltd.			
Mildred Lake Mining and Upgrading, Upgrader Expansion and Emissions Reduction Program (ERP)	existing/approved	162.79	NNW
Aurora South Mine	approved	176.24	NNW
Aurora North Mine	existing/approved	188.12	NNW
Birch Mountain Resources Ltd.			
Muskeg Valley Quarry	existing/approved	176.89	NNW
Hammerstone Project	planned	177.72	NNW
Albian Sands Energy Inc.			
Muskeg River Mine and Muskeg River Mine Expansion	existing/approved	183.73	NNW
Total E&P Joslyn Ltd.			
Joslyn Creek SAGD Project – Phase 1 and Commercial	existing/approved	193.19	NNW
Joslyn Creek SAGD Expansion Project	planned	193.17	NNW
Joslyn North Mine Project	planned	192.69	NNW
Petro-Canada Oil Sands Inc.			
Fort Hills Oil Sands Project	approved	199.03	NNW
Synenco Energy Inc.			
Northern Lights Project	planned	210.76	N

(a) Distance and direction are relative to the Central Plant Site.

Table 1.9-2 summarizes the PDC emission rates assumed for the industrial and non-industrial sources included in the modelling domain. A detailed summary of the emission rates from PDC sources is presented in Appendix 3-II.

Table 1.9-2 Summary of Planned Development Case Emissions

Source	Emission Rates[a]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
MEG Energy Christina Lake Pilot	0.00	0.00	0.21	0.19	0.02	0.01	0.00
MEG Energy Christina Lake Phase 2	0.01	0.01	2.76	1.72	0.15	0.08	0.01
MEG Energy Christina Lake Phase 2B	1.85	1.85	3.52	2.41	0.21	0.12	0.01
MEG Energy Christina Lake Phases 3A and 3B	0.91	0.91	9.61	8.68	0.78	0.60	0.04
other industry south of Fort McMurray[b]	74.51	79.35	151.13	149.87	9.97	16.13[c]	0.60[c]
other industry north of Fort McMurray[b]	160.32	227.84	486.84	363.90	29.81	850.81[c]	8.58[c]
Communities	0.19	0.19	0.92	—[d]	—[d]	2.13	0.00
Total[e]	**237.79**	**310.16**	**654.98**	**526.77**	**40.93**	**869.88**	**9.24**

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

[b] Includes the emissions from other oil sands developments and industrial sources in the modelling domain.

[c] Volatile Organic Compounds (VOC) and Total Reduced Sulphur (TRS) emissions include variable pond emission rates from the Suncor, Canadian Natural and Imperial Oil developments as discussed in Appendix 3-II. Emissions presented above include the maximum daily emission rate from these developments.

[d] Background data were added to model predictions to represent CO and $PM_{2.5}$ emissions from the communities. Therefore, community emissions of CO and $PM_{2.5}$ were not modelled. A description of the background data used is provided in Appendix 3-II.

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

1.9.3 Key Question AQPDC-1: What Effects Could the Project, the Existing and Approved Developments and Planned Developments Have on Ambient Air Quality in the Region?

1.9.3.1 Impact Analysis

The first stage of the evaluation examined the change in air emission rates associated with the PDC sources within the RSA. The EAC, Project Case and PDC emission rates are summarized in Table 1.9-3 for the RSA. The PDC emission rates in the RSA are estimated to increase by 31.9% for SO_2, 105.3%

for NO_X, 102.4% for CO, 171.5% for $PM_{2.5}$, 470.4% for VOCs and 357.4% for TRS compared with those in the EAC.

Table 1.9-3 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Air Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Planned Development Case
SO_2 emissions [t/sd]	10.81	12.06	14.26
SO_2 emissions [t/cd]	10.81	12.06	14.26
NO_X emissions [t/d]	26.52	36.14	54.45
CO emissions [t/d]	23.65	32.32	47.85
$PM_{2.5}$ emissions [t/d]	1.33	2.12	3.62
VOC emissions [t/d]	1.29	1.88	7.36
TRS emissions [t/d]	0.08	0.13	0.38

The effect of emissions associated with the PDC on ground-level concentrations in the region were estimated using air dispersion modelling. Concentrations of SO_2, NO_2, CO, H_2S, selected TRS compounds, benzene, selected VOCs, $PM_{2.5,}$ selected PAH compounds and selected trace metals were predicted using the CALPUFF model (3-D mode). The modelling results were compared to AAAQOs, Canadian Federal Air Quality Objectives, the CWS or other criteria, where applicable. Some parameters (e.g., VOCs, PAHs and trace metals) have the potential to affect the health of the people and wildlife in the region. The dispersion modelling results for these compounds have been assessed in the Environmental Health section (Section 3). The PDC ambient predictions are detailed in Appendix 3-III.

Table 1.9-4 presents the maximum predicted ground-level SO_2 concentrations (excluding developed areas) within the LSA and RSA for the Project cases. The SO_2 concentrations in the RSA and LSA are below the 1-hour, 24-hour and annual AAAQOs for all three cases.

Table 1.9-5 presents the maximum predicted ground-level NO_2 concentrations (excluding developed areas) within the LSA and RSA for the EAC, Project and PDC. The NO_2 concentrations in the RSA and LSA are below the 1-hour, 24-hour and annual AAAQOs for all three cases.

In addition to evaluating the air quality across the region, the PDC air quality assessment includes the ground-level concentrations of SO_2, NO_2, CO, H_2S, selected TRS compounds, benzene, selected VOCs, $PM_{2.5}$, selected PAH compounds and selected trace metals at the selected receptors. Some of these compounds have ambient air quality criteria that can be used to evaluate the possible effects of the air emissions from regional sources on the air quality at the selected receptors. Modelling results of all compounds, including those without air quality guidelines and standards, were provided to other disciplines for evaluation. A summary of these evaluations has been presented in the Human Health Risk Assessment (Section 3).

Table 1.9-4 Comparison of Regional Existing and Approved Case, Project Case and Planned Development Case Sulphur Dioxide Predictions

Parameter	Existing and Approved Case	Project Case	Planned Development Case
LSA			
maximum 1-hour SO_2 (excluding developed areas)(a)(b) [µg/m³]	283.1	416.1	416.3
occurrences above 1-hour AAAQO(c)(d)	0	0	0
area above 1-hour AAAQO (excluding developed areas)(b)(c) [ha]	0	0	0
maximum 24-hour SO_2 (excluding developed areas)(a)(b) [µg/m³]	66.0	118.6	119.8
occurrences above 24-hour AAAQO(d)(e)	0	0	0
area above 24-hour AAAQO (excluding developed areas)(b)(e) [ha]	0	0	0
maximum annual average SO_2 (excluding developed areas)(a)(b) [µg/m³]	7.4	15.6	15.5
occurrences above annual AAAQO(d)(f)	0	0	0
area above annual AAAQO (excluding developed areas)(b)(f) [ha]	0	0	0
RSA			
maximum 1-hour SO_2 (excluding developed areas)(a)(b) [µg/m³]	283.1	416.1	416.3
occurrences above 1-hour AAAQO(c)(d)	0	0	0
area above 1-hour AAAQO (excluding developed areas)(b)(c) [ha]	0	0	0
maximum 24-hour SO_2 (excluding developed areas)(a)(b) [µg/m³]	66.0	118.6	119.8
occurrences above 24-hour AAAQO(d)(e)	0	0	0
area above 24-hour AAAQO (excluding developed areas)(b)(e) [ha]	0	0	0
maximum annual average SO_2 (excluding developed areas)(a)(b) [µg/m³]	7.4	15.6	15.5
occurrences above annual AAAQO(d)(f)	0	0	0
area above annual AAAQO (excluding developed areas)(b)(f) [ha]	0	0	0

(a) Maximum predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(b) Developed areas include the Project plant sites.

(c) The 1-hour Alberta Ambient Air Quality Objective for SO_2 is 450 µg/m³.

(d) The number of occurrences is based on the concentrations outside of developed areas.

(e) The 24-hour Alberta Ambient Air Quality Objective for SO_2 is 150 µg/m³.

(f) The annual Alberta Ambient Air Quality Objective for SO_2 is 30 µg/m³.

Table 1.9-5 Comparison of Regional Existing and Approved Case, Project Case and Planned Development Nitrogen Dioxide Predictions

Parameter	Existing and Approved Case	Project Case	Planned Development Case
Local Study Area (LSA)			
maximum 1-hour NO_2 (excluding developed areas)[(a)(b)] [µg/m³]	87.9	161.4	161.4
occurrences above 1-hour AAAQO[(c)(d)]	0	0	0
area above 1-hour AAAQO (excluding developed areas)[(b)(c)] [ha]	0	0	0
maximum 24-hour NO_2 (excluding developed areas)[(a)(b)] [µg/m³]	41.8	46.4	50.2
occurrences above 24-hour AAAQO[(d)(e)]	0	0	0
area above 24-hour AAAQO (excluding developed areas)[(b)(e)] [ha]	0	0	0
maximum annual average NO_2 (excluding developed areas)[(a)(b)] [µg/m³]	3.8	6.1	7.1
occurrences above annual AAAQO[(d)(f)]	0	0	0
area above annual AAAQO (excluding developed areas)[(b)(f)] [ha]	0	0	0
Regional Study Area (RSA)			
maximum 1-hour NO_2 (excluding developed areas)[(a)(b)] [µg/m³]	158.1	161.4	161.4
occurrences above 1-hour AAAQO[(c)(d)]	0	0	0
area above 1-hour AAAQO (excluding developed areas)[(b)(c)] [ha]	0	0	0
maximum 24-hour NO_2 (excluding developed areas)[(a)(b)] [µg/m³]	65.6	65.7	67.8
occurrences above 24-hour AAAQO[(d)(e)]	0	0	0
area above 24-hour AAAQO (excluding developed areas)[(b)(e)] [ha]	0	0	0
maximum annual average NO_2 (excluding developed areas)[(a)(b)] [µg/m³]	5.5	6.1	7.1
occurrences above annual AAAQO[(d)(f)]	0	0	0
area above annual AAAQO (excluding developed areas)[(b)(f)] [ha]	0	0	0

(a) Maximum predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(b) Developed areas include the Project plant sites.

(c) The 1-hour Alberta Ambient Air Quality Objective for NO_2 is 400 µg/m³.

(d) The number of occurrences is based on the concentrations outside of developed areas.

(e) The 24-hour Alberta Ambient Air Quality Objective for NO_2 is 200 µg/m³.

(f) The annual Alberta Ambient Air Quality Objective for NO_2 is 60 µg/m³.

Table 1.9-6 presents the maximum predicted ground-level SO_2 concentrations at the selected receptors for the EAC, Project Case and PDC. The modelling results indicate that SO_2 concentrations are below the 1-hour, 24-hour and annual AAAQOs for all three cases. Several of the SO_2 predictions decreased from the Project Case to the PDC. This change is attributed to the expected decrease in the SO_2 emission rate from the EnCana Christina Lake Project in the PDC.

Table 1.9-7 presents the maximum predicted ground-level NO_2 concentrations at the selected receptors for the EAC, Project Case and PDC. The predicted NO_2 concentrations are below the 1-hour, 24-hour and annual AAAQOs for all three cases.

Table 1.9-6 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Sulphur Dioxide Predictions at Selected Receptors

Receptor	Maximum 1-Hour SO_2[a][b]			Peak 24-Hour SO_2[a][c]			Peak Annual Average SO_2[a][d]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	17.3	17.8	19.5	9.3	9.9	12.2	1.16	1.20	1.36
Janvier/Chard (IR 194)	25.6	25.6	31.7	13.4	13.4	17.3	1.49	1.52	1.80
Winefred Lake (IR 194B)	18.4	19.0	20.1	10.4	11.3	14.1	1.68	1.82	1.79
Hunter/Trapper A	60.8	60.8	27.3	19.6	19.9	13.5	2.52	2.70	2.19
Hunter/Trapper B	22.8	24.7	25.4	12.0	12.0	15.6	1.40	1.46	1.69
Operator's Residence	46.4	46.4	35.0	23.8	23.8	13.7	2.51	2.78	2.32
Christina Lake Lodge	19.9	20.6	22.0	9.5	9.9	12.1	1.15	1.19	1.36
Maximum Property Boundary	281.6	416.1	416.3	66.0	118.5	119.8	6.53	15.63	15.53

[a] Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the peak 24-hour and annual values.

[b] The 1-hour Alberta Ambient Air Quality Objective for SO_2 is 450 µg/m³.

[c] The 24-hour Alberta Ambient Air Quality Objective for SO_2 is 150 µg/m³.

[d] The annual Alberta Ambient Air Quality Objective for SO_2 is 30 µg/m³.

Table 1.9-7 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Nitrogen Dioxide Predictions at Selected Receptors

Receptor	Maximum 1-Hour NO_2[(a)(b)]			Peak 24-Hour NO_2[(a)(c)]			Peak Annual Average NO_2[(a)(d)]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	84.4	84.4	87.6	31.0	31.3	34.8	3.72	3.93	4.76
Janvier/Chard (IR 194)	56.7	56.7	66.3	24.7	24.8	30.7	3.84	3.99	5.07
Winefred Lake (IR 194B)	20.6	54.1	59.5	11.5	18.4	20.8	2.26	3.83	4.53
Hunter/Trapper A	26.9	29.5	33.9	11.7	13.0	18.3	2.58	3.03	3.87
Hunter/Trapper B	29.9	31.3	39.0	14.9	15.0	21.1	2.24	2.92	3.97
Operator's Residence	31.1	31.8	37.7	12.0	13.3	18.6	2.72	3.23	4.02
Christina Lake Lodge	37.1	37.1	42.5	13.2	13.2	17.6	2.27	2.50	3.33
Maximum Property Boundary	84.8	156.1	157.4	41.8	44.6	44.6	3.77	5.07	6.12

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the peak 24-hour and annual values.

(b) The 1-hour Alberta Ambient Air Quality Objective for NO_2 is 400 µg/m³.

(c) The 24-hour Alberta Ambient Air Quality Objective for NO_2 is 200 µg/m³.

(d) The annual Alberta Ambient Air Quality Objective for NO_2 is 60 µg/m³.

Tables 1.9-8 to 1.9-11 present the predicted ground-level CO, H_2S, COS and CS_2 concentrations, respectively, at the selected receptors. The peak CO, H_2S and CS_2 concentrations at the selected receptors are below the applicable AAAQOs for all three cases. The peak 1-hour CO prediction at Hunter/Trapper A dropped slightly from the Project Case to the PDC, and is likely due to the expected change in stack parameters at the EnCana Christina Lake Project in the Planned Development Case.

Table 1.9-12 presents the peak predicted ground-level benzene concentrations at the selected receptors for the EAC, Project Case and PDC. The results indicated that benzene concentrations are below the 1-hour AAAQO of 30 µg/m³ for all three cases.

Table 1.9-13 presents predicted ground-level concentrations of select VOC compounds at the selected receptors. The predicted peak VOC concentrations are below the AAAQOs and other criteria, as applicable, for all three cases. This table shows that the peak 1-hour benzene concentration at Janvier/Chard (IR 194) decreases from the Project Case to the PDC. Again, this is likely due to the expected change in stack parameters at the EnCana Christina Lake Project in the PDC.

Table 1.9-14 presents the predicted ground-level $PM_{2.5}$ concentrations for the EAC, Project Case and PDC. The results indicate that the peak 1-hour and 24-hour $PM_{2.5}$ concentrations at the selected receptors are below the AAAQOs for all three cases. However, at the Maximum Property Boundary, the peak predicted 1-hour $PM_{2.5}$ concentration is above the 80 µg/m³ AAAQO for the Project Case and PDC.

The air quality assessment also includes an evaluation of selected PAH and trace metal compounds. Tables 1.9-15, 1.9-16 and 1.9-17 present predicted ground-level concentrations of PAH and trace metals at the selected receptors for the EAC, Project Case and PDC. The predicted peak PAH and metal concentrations are below the AAAQOs and other criteria, as applicable, for all three cases. Several of the metal compounds concentrations decrease from the Project Case to the PDC (i.e., at the fourth decimal place). This is likely due to rounding errors.

Table 1.9-8 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Carbon Monoxide Predictions at Selected Receptors

Receptor	Peak 1-Hour CO[(a)(b)]			Peak 8-Hour CO[(a)(c)]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	347.7	347.7	348.5	164.9	165.0	168.6
Janvier/Chard (IR 194)	421.7	421.8	429.4	255.7	255.7	262.0
Winefred Lake (IR 194B)	45.7	80.9	88.6	34.0	43.5	48.6
Hunter/Trapper A	46.9	47.2	46.7	28.4	30.7	36.0
Hunter/Trapper B	55.6	55.6	63.5	43.3	43.3	49.7
Operator’s Residence	55.5	55.6	55.6	30.0	32.7	38.0
Christina Lake Lodge	58.4	58.4	68.0	27.4	27.6	32.6
Maximum Property Boundary	433.2	1,153.2	1,156.2	129.9	370.0	370.5

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

(b) The 1-hour Alberta Ambient Air Quality Objective for CO is 15,000 µg/m³.

(c) The 8-hour Alberta Ambient Air Quality Objective for CO is 6,000 µg/m³.

Note: There is no annual Alberta Ambient Air Quality Objective for CO.

Table 1.9-9 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Hydrogen Sulphide Predictions at Selected Receptors

Receptor	Peak 1-Hour H_2S[a][b]			Peak 24-Hour H_2S[a][c]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	0.85	0.85	0.85	0.13	0.13	0.14
Janvier/Chard (IR 194)	0.18	0.18	0.19	0.06	0.06	0.07
Winefred Lake (IR 194B)	0.14	0.39	0.40	0.05	0.15	0.16
Hunter/Trapper A	0.21	0.23	0.23	0.08	0.09	0.09
Hunter/Trapper B	0.21	0.23	0.24	0.05	0.05	0.06
Operator’s Residence	0.42	0.42	0.43	0.14	0.15	0.15
Christina Lake Lodge	0.34	0.34	0.35	0.08	0.08	0.09
Maximum Property Boundary	5.97	8.33	8.33	2.49	3.55	3.55

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

[b] The 1-hour Alberta Ambient Air Quality Objective for H_2S is 14 µg/m³.

[c] The 24-hour Alberta Ambient Air Quality Objective for H_2S is 4 µg/m³.

Note: There is no annual Alberta Ambient Air Quality Objective for H_2S.

Table 1.9-10 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Carbonyl Sulphide Predictions at Selected Receptors

Receptor	Peak 1-Hour COS[a]			Peak Annual Average COS[a]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	0.015	0.015	0.019	0.001	0.001	0.001
Janvier/Chard (IR 194)	0.042	0.042	0.047	0.001	0.001	0.001
Winefred Lake (IR 194B)	0.022	0.022	0.026	0.001	0.001	0.001
Hunter/Trapper A	0.020	0.020	0.024	0.001	0.001	0.001
Hunter/Trapper B	0.030	0.030	0.034	0.001	0.001	0.001
Operator’s Residence	0.020	0.020	0.025	0.001	0.001	0.001
Christina Lake Lodge	0.017	0.017	0.021	0.001	0.001	0.001
Maximum Property Boundary	0.215	0.299	0.299	0.010	0.018	0.018

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

Note: There are no Alberta Ambient Air Quality Objectives for COS.

Table 1.9-11 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Carbon Disulphide Predictions at Selected Receptors

Receptor	Peak 1-Hour CS_2[(a)(b)]			Peak Annual Average CS_2[(a)]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	0.015	0.015	0.019	0.001	0.001	0.001
Janvier/Chard (IR 194)	0.040	0.040	0.045	0.001	0.001	0.001
Winefred Lake (IR 194B)	0.021	0.024	0.025	0.001	0.001	0.001
Hunter/Trapper A	0.019	0.019	0.022	0.001	0.001	0.001
Hunter/Trapper B	0.029	0.029	0.033	0.001	0.001	0.001
Operator’s Residence	0.024	0.025	0.025	0.001	0.001	0.001
Christina Lake Lodge	0.015	0.015	0.019	0.001	0.001	0.001
Maximum Property Boundary	0.347	0.484	0.484	0.015	0.028	0.028

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

(b) The 1-hour Alberta Ambient Air Quality Objective for CS_2 is 30 µg/m³.

Note: There are no 24-hour or annual Alberta Ambient Air Quality Objective for CS_2.

Table 1.9-12 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Benzene Predictions at Selected Receptors

Receptor	Peak 1-Hour Benzene[(a)(b)]		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	0.6	0.6	0.6
Janvier/Chard (IR 194)	0.4	0.4	0.4
Winefred Lake (IR 194B)	0.2	0.2	0.2
Hunter/Trapper A	0.3	0.3	0.3
Hunter/Trapper B	0.3	0.3	0.3
Operator's Residence	0.3	0.3	0.3
Christina Lake Lodge	0.2	0.2	0.2
Maximum Property Boundary	0.3	0.3	0.3

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

(b) The 1-hour Alberta Ambient Air Quality Objective for benzene is 30 µg/m³.

Note: There are no 24-hour or annual Alberta Ambient Air Quality Objectives for benzene.

Table 1.9-13 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Volatile Organic Compound Predictions at Selected Receptors

Averaging Period and Parameter[(a)(b)]	Conklin			Janvier/Chard (IR 194)		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Project Development Case [µg/m³])	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Project Development Case [µg/m³]
Peak 1-hour benzene	0.579080	0.579110	0.581390	0.411930	0.411930	0.408690
Peak 1-hour trimethylbenzene	0.287960	0.287960	0.358440	0.622800	0.622800	0.804300
Peak annual trimethylbenzene	0.006897	0.006897	0.010138	0.009776	0.009776	0.014876
Peak 1-hour hexane	4.637600	4.637600	5.867200	17.823000	17.823000	22.164000
Peak annual hexane	0.124958	0.128590	0.185584	0.210808	0.213593	0.301848
Peak 1-hour acrolein	0.338960	0.338960	0.339140	0.086463	0.086462	0.108760
Peak annual acrolein	0.007036	0.007036	0.007417	0.003439	0.003439	0.004025
Peak 1-hour 1,3-butadiene	0.017802	0.017802	0.017815	0.007747	0.007747	0.009774
Peak annual 1,3-butadiene	0.000521	0.000521	0.000556	0.000264	0.000264	0.000317
Peak 1-hour formaldehyde	3.483600	3.483700	3.504900	0.626500	0.626510	0.791990
Peak 1-hour 1,1,1-trichloroethane	0.000128	0.000128	0.000128	0.000017	0.000017	0.000017
Peak annual 1,1,1-trichloroethane	0.000006	0.000006	0.000006	0.000001	0.000001	0.000001
Peak 1-hour acetaldehyde	0.843290	0.843290	0.849190	1.026100	1.026100	1.298700
Peak 1-hour acetone	0.428360	0.428360	0.431460	0.536420	0.536420	0.679010
Peak 1-hour cumene	0.402190	0.402190	0.545630	1.065000	1.065100	1.338700
Peak 1-hour ethylbenzene	1.347900	1.347900	1.492100	2.471700	2.471700	2.793200
Peak 1-hour ethylene	2.241800	2.241800	2.243100	0.255230	0.255230	0.311240
Peak annual ethylene	0.106981	0.106989	0.108543	0.022616	0.022619	0.024775
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 1.9-13 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter(a)(b)	**Conklin**			**Janvier/Chard (IR 194)**		
	Existing and Approved Case [µg/m^3]	**Project Case [µg/m^3]**	**Project Development Case [µg/m^3])**	**Existing and Approved Case [µg/m^3]**	**Project Case [µg/m^3]**	**Project Development Case [µg/m^3]**
Peak 1-hour toluene	1.958900	1.958900	2.438900	4.288700	4.288700	5.479900
Peak 1-hour xylenes	2.110400	2.110400	2.628000	5.599900	5.599900	6.746500
Peak 1-hour 1,1,2-trichloroethanes	0.002066	0.002066	0.002066	0.000210	0.000210	0.000210
Peak annual 1,1,2-trichloroethanes	0.000019	0.000019	0.000019	0.000008	0.000008	0.000008
Peak 1-hour 1,2-dichloropropane	0.001748	0.001748	0.001748	0.000178	0.000178	0.000178
Peak annual 1,2-dichloropropane	0.000016	0.000016	0.000016	0.000007	0.000007	0.000007
Peak 1-hour 1,3-dichloropropene	0.001715	0.001715	0.001715	0.000174	0.000174	0.000174
Peak annual 1,3-dichloropropene	0.000016	0.000016	0.000016	0.000006	0.000006	0.000006
Peak 1-hour carbon tetrachloride	0.002384	0.002384	0.002384	0.000242	0.000242	0.000242
Peak annual carbon tetrachloride	0.000022	0.000022	0.000022	0.000009	0.000009	0.000009
Peak 1-hour chlorobenzene	0.001975	0.001975	0.001975	0.000201	0.000201	0.000201
Peak annual chlorobenzene	0.000018	0.000018	0.000018	0.000007	0.000007	0.000007
Peak 1-hour chloroethane	0.000121	0.000121	0.000121	0.000012	0.000012	0.000012
Peak annual chloroethane	0.000001	0.000001	0.000001	0.000000	0.000000	0.000000
Peak 1-hour chloroform	0.001852	0.001852	0.001852	0.000188	0.000188	0.000188
Peak annual chloroform	0.000017	0.000017	0.000017	0.000007	0.000007	0.000007
Peak 1-hour methanol	0.162410	0.162410	0.162410	0.016513	0.016513	0.016513
Peak 1-hour methylene chloride	0.001299	0.001299	0.001299	0.000132	0.000132	0.000132
Peak annual methylene chloride	0.000012	0.000012	0.000012	0.000005	0.000005	0.000005
Peak 1-hour phenol	0.001559	0.001559	0.001559	0.000159	0.000159	0.000159
Peak 1-hour vinyl chloride	0.000968	0.000968	0.000968	0.000098	0.000098	0.000098
Peak 1-hour styrene	0.001533	0.001533	0.001533	0.000156	0.000156	0.000156
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.001147	0.001147	0.001502	0.001597	0.001597	0.002453
Peak annual propylene oxide	0.000040	0.000040	0.000072	0.000056	0.000056	0.000105

Table 1.9-13 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter(a)(b)	Winefred Lake (IR 194B)			Hunter/Trapper A		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Project Development Case [µg/m^3])	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Project Development Case [µg/m^3])
Peak 1-hour benzene	0.196200	0.196200	0.204330	0.264080	0.264090	0.266550
Peak 1-hour trimethylbenzene	0.334320	0.334320	0.410940	0.456950	0.456950	0.566910
Peak annual trimethylbenzene	0.006492	0.006493	0.010182	0.006501	0.006501	0.010131
Peak 1-hour hexane	8.058300	8.059000	9.857400	10.853000	10.860000	13.337000
Peak annual hexane	0.144294	0.169286	0.231196	0.145776	0.153390	0.216461
Peak 1-hour acrolein	0.041927	0.041926	0.055209	0.039168	0.039168	0.051706
Peak annual acrolein	0.002025	0.002025	0.002424	0.002312	0.002312	0.002723
Peak 1-hour 1,3-butadiene	0.003768	0.003768	0.004975	0.003519	0.003519	0.004608
Peak annual 1,3-butadiene	0.000151	0.000151	0.000187	0.000165	0.000165	0.000203
Peak 1-hour formaldehyde	0.312890	0.316400	0.421060	0.327990	0.328270	0.395010
Peak 1-hour 1,1,1-trichloroethane	0.000028	0.000028	0.000028	0.000022	0.000022	0.000022
Peak annual 1,1,1-trichloroethane	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Peak 1-hour acetaldehyde	0.500580	0.500580	0.662830	0.467260	0.467260	0.606830
Peak 1-hour acetone	0.261740	0.261740	0.346570	0.244600	0.244600	0.316070
Peak 1-hour cumene	0.595830	0.595830	0.744040	0.668140	0.668140	0.828670
Peak 1-hour ethylbenzene	1.468500	1.468500	1.663700	1.320800	1.320800	1.495900
Peak 1-hour ethylene	0.122380	0.122410	0.159030	0.115080	0.115090	0.143390
Peak annual ethylene	0.004025	0.004077	0.005470	0.004141	0.004156	0.005688
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	2.335000	2.335100	2.861000	3.116900	3.116900	3.855500
Peak 1-hour xylenes	2.799900	2.799900	3.381100	2.974500	2.974500	3.678500
Peak 1-hour 1,1,2-trichloroethanes	0.000132	0.000132	0.000132	0.000177	0.000177	0.000177
Peak annual 1,1,2-trichloroethanes	0.000005	0.000005	0.000005	0.000007	0.000007	0.000007
Peak 1-hour 1,2-dichloropropane	0.000112	0.000112	0.000112	0.000150	0.000150	0.000150
Peak annual 1,2-dichloropropane	0.000004	0.000004	0.000004	0.000006	0.000006	0.000006
Peak 1-hour 1,3-dichloropropene	0.000110	0.000110	0.000110	0.000147	0.000147	0.000147
Peak annual 1,3-dichloropropene	0.000004	0.000004	0.000004	0.000006	0.000006	0.000006
Peak 1-hour carbon tetrachloride	0.000153	0.000153	0.000153	0.000205	0.000205	0.000205
Peak annual carbon tetrachloride	0.000006	0.000006	0.000006	0.000008	0.000008	0.000008
Peak 1-hour chlorobenzene	0.000126	0.000126	0.000126	0.000170	0.000170	0.000170
Peak annual chlorobenzene	0.000005	0.000005	0.000005	0.000007	0.000007	0.000007
Peak 1-hour chloroethane	0.000008	0.000008	0.000008	0.000010	0.000010	0.000010
Peak annual chloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour chloroform	0.000119	0.000119	0.000119	0.000159	0.000159	0.000159
Peak annual chloroform	0.000005	0.000005	0.000005	0.000006	0.000006	0.000006
Peak 1-hour methanol	0.010402	0.010402	0.010402	0.013950	0.013950	0.013950
Peak 1-hour methylene chloride	0.000083	0.000083	0.000083	0.000112	0.000112	0.000112
Peak annual methylene chloride	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004
Peak 1-hour phenol	0.000100	0.000100	0.000100	0.000134	0.000134	0.000134
Peak 1-hour vinyl chloride	0.000062	0.000062	0.000062	0.000083	0.000083	0.000083
Peak 1-hour styrene	0.000098	0.000098	0.000098	0.000132	0.000132	0.000132
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.002176	0.002176	0.002203	0.005201	0.005201	0.005214
Peak annual propylene oxide	0.000084	0.000084	0.000117	0.000069	0.000069	0.000104

Table 1.9-13 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter(a)(b)	Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Project Development Case [µg/m^3])	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Project Development Case [µg/m^3])
Peak 1-hour benzene	0.272570	0.272580	0.307210	0.262450	0.262450	0.263700
Peak 1-hour trimethylbenzene	0.457470	0.457470	0.585700	0.449750	0.449750	0.557100
Peak annual trimethylbenzene	0.007911	0.007911	0.012202	0.006605	0.006605	0.010291
Peak 1-hour hexane	11.223000	11.223000	14.260000	10.834000	10.835000	13.289000
Peak annual hexane	0.170074	0.180786	0.256718	0.149937	0.158384	0.221969
Peak 1-hour acrolein	0.059498	0.059498	0.077576	0.039611	0.039611	0.052461
Peak annual acrolein	0.002635	0.002635	0.003128	0.002309	0.002309	0.002726
Peak 1-hour 1,3-butadiene	0.005353	0.005353	0.006996	0.003568	0.003568	0.004709
Peak annual 1,3-butadiene	0.000191	0.000191	0.000236	0.000166	0.000166	0.000204
Peak 1-hour formaldehyde	0.426300	0.426330	0.570280	0.352890	0.353200	0.400110
Peak 1-hour 1,1,1-trichloroethane	0.000021	0.000021	0.000021	0.000023	0.000023	0.000023
Peak annual 1,1,1-trichloroethane	0.000000	0.000000	0.000000	0.000001	0.000001	0.000001
Peak 1-hour acetaldehyde	0.712080	0.712070	0.932940	0.475210	0.475210	0.626870
Peak 1-hour acetone	0.372690	0.372680	0.488170	0.248980	0.248980	0.327790
Peak 1-hour cumene	0.762030	0.762030	0.970250	0.670260	0.670260	0.828140
Peak 1-hour ethylbenzene	1.913100	1.913100	2.160500	1.363600	1.363600	1.541700
Peak 1-hour ethylene	0.176070	0.176070	0.223840	0.117260	0.117260	0.149240
Peak annual ethylene	0.004845	0.004867	0.006818	0.004190	0.004208	0.005749
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	3.159800	3.159800	4.008200	3.073800	3.073800	3.794200
Peak 1-hour xylenes	4.119700	4.119700	4.991800	3.024000	3.024000	3.727100
Peak 1-hour 1,1,2-trichloroethanes	0.000198	0.000198	0.000198	0.000192	0.000192	0.000192
Peak annual 1,1,2-trichloroethanes	0.000008	0.000008	0.000008	0.000007	0.000007	0.000007
Peak 1-hour 1,2-dichloropropane	0.000167	0.000167	0.000167	0.000163	0.000163	0.000163
Peak annual 1,2-dichloropropane	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Peak 1-hour 1,3-dichloropropene	0.000164	0.000164	0.000164	0.000160	0.000160	0.000160
Peak annual 1,3-dichloropropene	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
Peak 1-hour carbon tetrachloride	0.000228	0.000228	0.000228	0.000222	0.000222	0.000222
Peak annual carbon tetrachloride	0.000009	0.000009	0.000009	0.000008	0.000008	0.000008
Peak 1-hour chlorobenzene	0.000189	0.000189	0.000189	0.000184	0.000184	0.000184
Peak annual chlorobenzene	0.000007	0.000007	0.000007	0.000007	0.000007	0.000007
Peak 1-hour chloroethane	0.000012	0.000012	0.000012	0.000011	0.000011	0.000011
Peak annual chloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour chloroform	0.000177	0.000177	0.000177	0.000172	0.000172	0.000172
Peak annual chloroform	0.000007	0.000007	0.000007	0.000006	0.000006	0.000006
Peak 1-hour methanol	0.015554	0.015554	0.015554	0.015116	0.015116	0.015116
Peak 1-hour methylene chloride	0.000124	0.000124	0.000124	0.000121	0.000121	0.000121
Peak annual methylene chloride	0.000005	0.000005	0.000005	0.000004	0.000004	0.000004
Peak 1-hour phenol	0.000149	0.000149	0.000149	0.000145	0.000145	0.000145
Peak 1-hour vinyl chloride	0.000093	0.000093	0.000093	0.000090	0.000090	0.000090
Peak 1-hour styrene	0.000147	0.000147	0.000147	0.000143	0.000143	0.000143
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.002566	0.002566	0.002600	0.012848	0.012848	0.012848
Peak annual propylene oxide	0.000059	0.000059	0.000101	0.000088	0.000088	0.000124

Table 1.9-13 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Volatile Organic Compound Predictions at Selected Receptors (continued)

Averaging Period and Parameter$^{(a)(b)}$	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Project Development Case [µg/m^3]$^{)}$	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Project Development Case [µg/m^3]$^{)}$
Peak 1-hour benzene	0.170360	0.170360	0.191720	0.252110	0.252110	0.261880
Peak 1-hour trimethylbenzene	0.361050	0.361050	0.452030	0.441250	0.441260	0.550240
Peak annual trimethylbenzene	0.005956	0.005956	0.009243	0.007166	0.007183	0.011076
Peak 1-hour hexane	6.420500	6.420500	8.084400	10.885000	16.695000	16.766001
Peak annual hexane	0.123859	0.127869	0.185648	0.270195	0.358152	0.427947
Peak 1-hour acrolein	0.089542	0.089542	0.090926	0.171360	0.171360	0.171720
Peak annual acrolein	0.003071	0.003071	0.003454	0.003673	0.003673	0.004125
Peak 1-hour 1,3-butadiene	0.004804	0.004804	0.004929	0.008939	0.008939	0.008973
Peak annual 1,3-butadiene	0.000203	0.000203	0.000238	0.000240	0.000240	0.000281
Peak 1-hour formaldehyde	0.909690	0.909730	0.922260	2.124200	2.126500	2.126500
Peak 1-hour 1,1,1-trichloroethane	0.000021	0.000021	0.000021	0.000028	0.000028	0.000028
Peak annual 1,1,1-trichloroethane	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Peak 1-hour acetaldehyde	0.357890	0.357890	0.479080	0.549310	0.549310	0.731120
Peak 1-hour acetone	0.187110	0.187110	0.250780	0.287160	0.287160	0.382130
Peak 1-hour cumene	0.506020	0.506020	0.641700	0.671680	0.671680	0.828100
Peak 1-hour ethylbenzene	1.225500	1.225500	1.364100	2.554100	2.554100	2.555300
Peak 1-hour ethylene	0.111600	0.111610	0.131990	0.135690	0.150420	0.192160
Peak annual ethylene	0.005304	0.005313	0.006821	0.006743	0.009022	0.010889
Peak 1-hour 2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour toluene	2.453500	2.453500	3.081000	3.005000	3.021500	3.745600
Peak 1-hour xylenes	2.113800	2.113800	2.615700	3.367200	3.368700	3.840600
Peak 1-hour 1,1,2-trichloroethanes	0.000530	0.000530	0.000530	0.001054	0.001054	0.001054
Peak annual 1,1,2-trichloroethanes	0.000012	0.000012	0.000012	0.000015	0.000015	0.000015
Peak 1-hour 1,2-dichloropropane	0.000448	0.000448	0.000448	0.000892	0.000892	0.000892
Peak annual 1,2-dichloropropane	0.000010	0.000010	0.000010	0.000013	0.000013	0.000013
Peak 1-hour 1,3-dichloropropene	0.000440	0.000440	0.000440	0.000875	0.000875	0.000875
Peak annual 1,3-dichloropropene	0.000010	0.000010	0.000010	0.000012	0.000012	0.000012
Peak 1-hour carbon tetrachloride	0.000612	0.000612	0.000612	0.001216	0.001216	0.001216
Peak annual carbon tetrachloride	0.000014	0.000014	0.000014	0.000017	0.000017	0.000017
Peak 1-hour chlorobenzene	0.000507	0.000507	0.000507	0.001008	0.001008	0.001008
Peak annual chlorobenzene	0.000012	0.000012	0.000012	0.000014	0.000014	0.000014
Peak 1-hour chloroethane	0.000031	0.000031	0.000031	0.000062	0.000062	0.000062
Peak annual chloroethane	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Peak 1-hour chloroform	0.000475	0.000475	0.000475	0.000945	0.000945	0.000945
Peak annual chloroform	0.000011	0.000011	0.000011	0.000013	0.000013	0.000013
Peak 1-hour methanol	0.041656	0.041656	0.041656	0.082866	0.082866	0.082866
Peak 1-hour methylene chloride	0.000333	0.000333	0.000333	0.000663	0.000663	0.000663
Peak annual methylene chloride	0.000008	0.000008	0.000008	0.000009	0.000009	0.000009
Peak 1-hour phenol	0.000400	0.000400	0.000400	0.000796	0.000796	0.000796
Peak 1-hour vinyl chloride	0.000248	0.000248	0.000248	0.000494	0.000494	0.000494
Peak 1-hour styrene	0.000393	0.000393	0.000393	0.000782	0.000782	0.000782
Peak 1-hour isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Peak 1-hour propylene oxide	0.000966	0.000966	0.001476	0.081733	0.081733	0.081733
Peak annual propylene oxide	0.000041	0.000041	0.000072	0.000738	0.000738	0.000775

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

[b] See Table 1.2-4 for respective air quality guidelines.

Table 1.9-14 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Particulate Matter Predictions at Selected Receptors

Receptor	Peak 1-Hour $PM_{2.5}$ (a)(b)			Peak 24-Hour $PM_{2.5}$ (a)(c)		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Conklin	24.5	24.6	30.2	16.9	17.1	21.0
Janvier/Chard (IR 194)	54.2	54.2	64.2	21.8	22.0	26.8
Winefred Lake (IR 194B)	34.3	34.4	44.4	13.8	14.5	18.8
Hunter/Trapper A	26.9	27.3	35.4	13.1	13.6	17.9
Hunter/Trapper B	37.0	37.0	47.2	14.6	14.9	19.6
Operator's Residence	28.3	29.1	37.8	13.3	13.8	18.2
Christina Lake Lodge	18.5	18.5	24.3	11.5	11.7	15.8
Maximum Property Boundary	45.6	**101.2**(d)	**101.4**(d)	16.2	19.5	24.0

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

(b) The 1-hour Alberta Ambient Air Quality Objective for $PM_{2.5}$ is 80 µg/m³.

(c) The 24-hour Alberta Ambient Air Quality Objective for $PM_{2.5}$ is 30 µg/m³.

(d) The maximum 1-hour $PM_{2.5}$ concentration (i.e., excluding the eight highest 1-hour predicted concentrations) is estimated to be 45.9 µg/m³ and 47.9 µg/m³ for the Project Case and PDC, respectively.

Table 1.9-15 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors

Averaging Period and Parameter[(a)]	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Peak 1-hour pyrenes and substitutes	0.000090	0.000090	0.000117	0.000117	0.000117	0.000167	0.000064	0.000066	0.000083
Peak annual pyrenes and substitutes	0.000003	0.000003	0.000004	0.000003	0.000003	0.000005	0.000003	0.000004	0.000005
Peak 1-hour fluorenes/fluoranthenes and substitutes	0.000446	0.000446	0.000478	0.000340	0.000340	0.000393	0.000193	0.000198	0.000228
Peak annual fluorenes/fluoranthenes and substitutes	0.000010	0.000010	0.000012	0.000010	0.000010	0.000013	0.000007	0.000009	0.000011
Peak 1-hour acenaphthenes/ acenaphthylenes	0.000445	0.000445	0.000465	0.000177	0.000178	0.000211	0.000096	0.000097	0.000118
Peak annual acenaphthenes/ acenaphthylenes	0.000007	0.000007	0.000008	0.000006	0.000006	0.000008	0.000004	0.000005	0.000006
Peak 1-hour anthracenes/ phenanthrenes and substitutes	0.000686	0.000686	0.000791	0.000409	0.000409	0.000596	0.000225	0.000239	0.000290
Peak annual anthracenes/ phenanthrenes and substitutes	0.000013	0.000014	0.000018	0.000012	0.000013	0.000020	0.000010	0.000015	0.000020
Peak 1-hour naphthalene and substitutes	0.007160	0.007169	0.010617	0.005550	0.005552	0.013268	0.003598	0.006911	0.008457
Peak annual naphthalene and substitutes	0.000190	0.000217	0.000325	0.000186	0.000202	0.000386	0.000184	0.000349	0.000468
Peak 1-hour biphenyl	0.013893	0.013893	0.013893	0.001412	0.001412	0.001412	0.000890	0.000890	0.000890
Peak annual biphenyl	0.000127	0.000127	0.000127	0.000053	0.000053	0.000053	0.000035	0.000035	0.000035

Table 1.9-15 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Averaging Period and Parameter[a]	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Planned Development Case [μg/m³]	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Planned Development Case [μg/m³]	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Planned Development Case [μg/m³]
Peak 1-hour pyrenes and substitutes	0.000077	0.000077	0.000081	0.000085	0.000085	0.000105	0.000122	0.000122	0.000122
Peak annual pyrenes and substitutes	0.000003	0.000004	0.000005	0.000003	0.000004	0.000005	0.000004	0.000004	0.000006
Peak 1-hour fluorenes/fluoranthenes and substitutes	0.000197	0.000198	0.000233	0.000264	0.000264	0.000303	0.000195	0.000195	0.000234
Peak annual fluorenes/fluoranthenes and substitutes	0.000008	0.000009	0.000011	0.000009	0.000009	0.000012	0.000009	0.000009	0.000011
Peak 1-hour acenaphthenes/ acenaphthylenes	0.000092	0.000092	0.000115	0.000130	0.000130	0.000156	0.000092	0.000092	0.000117
Peak annual acenaphthenes/ acenaphthylenes	0.000005	0.000005	0.000006	0.000005	0.000005	0.000007	0.000005	0.000006	0.000007
Peak 1-hour anthracenes/ phenanthrenes and substitutes	0.000300	0.000300	0.000302	0.000299	0.000299	0.000369	0.000473	0.000473	0.000473
Peak annual anthracenes/ phenanthrenes and substitutes	0.000012	0.000014	0.000019	0.000012	0.000014	0.000020	0.000015	0.000016	0.000021
Peak 1-hour naphthalene and substitutes	0.009786	0.009786	0.009786	0.005757	0.006347	0.007778	0.015438	0.015438	0.015438
Peak annual naphthalene and substitutes	0.000238	0.000292	0.000410	0.000190	0.000260	0.000410	0.000311	0.000368	0.000491
Peak 1-hour biphenyl	0.001193	0.001193	0.001193	0.001331	0.001331	0.001331	0.001293	0.001293	0.001293
Peak annual biphenyl	0.000048	0.000048	0.000048	0.000052	0.000052	0.000052	0.000047	0.000047	0.000047

Table 1.9-15 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Averaging Period and Parameter[a]	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Planned Development Case [μg/m³]	Existing and Approved Case [μg/m³]	Project Case [μg/m³]	Planned Development Case [μg/m³]
Peak 1-hour pyrenes and substitutes	0.000044	0.000044	0.000067	0.001858	0.001859	0.001868
Peak annual pyrenes and substitutes	0.000003	0.000003	0.000004	0.000079	0.000079	0.000081
Peak 1-hour fluorenes/fluoranthenes and substitutes	0.000158	0.000158	0.000180	0.002170	0.002171	0.002182
Peak annual fluorenes/fluoranthenes and substitutes	0.000008	0.000008	0.000010	0.000096	0.000097	0.000099
Peak 1-hour acenaphthenes/ acenaphthylenes	0.000119	0.000120	0.000130	0.001344	0.001345	0.001351
Peak annual acenaphthenes/ acenaphthylenes	0.000005	0.000005	0.000007	0.000059	0.000060	0.000061
Peak 1-hour anthracenes/ phenanthrenes and subtitutes	0.000190	0.000192	0.000251	0.007213	0.007216	0.007249
Peak annual anthracenes/ phenanthrenes and subtitutes	0.000011	0.000012	0.000016	0.000306	0.000308	0.000313
Peak 1-hour naphthalene and substitutes	0.002529	0.002557	0.006413	0.235410	0.235520	0.236530
Peak annual naphthalene and substitutes	0.000165	0.000193	0.000300	0.009841	0.009906	0.010037
Peak 1-hour biphenyl	0.003563	0.003563	0.003563	0.007085	0.007085	0.007085
Peak annual biphenyl	0.000081	0.000081	0.000081	0.000100	0.000100	0.000100

[a] The peak predictions include the eight highest 1-hour predictions from the CALPUFF model.

Note: There are no Alberta Ambient Air Quality Objectives for PAH compounds.

Table 1.9-16 Comparison of the Existing and Approved Case, Project Case and Planned Development Case 1-Hour Trace Metal Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]
Peak 1-Hour [µg/m^3](a)									
aluminum	0.002499	0.002499	0.002636	0.004875	0.004875	0.005209	0.002747	0.002747	0.002961
antimony	0.000135	0.000135	0.000135	0.000165	0.000165	0.000165	0.000170	0.000170	0.000170
arsenic(b)	0.000062	0.000063	0.000081	0.000100	0.000100	0.000114	0.000080	0.000166	0.000176
barium	0.000888	0.000925	0.001289	0.001516	0.001518	0.001813	0.001094	0.003641	0.003845
beryllium	0.000004	0.000005	0.000006	0.000008	0.000008	0.000009	0.000005	0.000010	0.000011
cadmium	0.000412	0.000412	0.000710	0.000938	0.000938	0.001326	0.000486	0.000920	0.000967
chromium(b)	0.001322	0.001322	0.001424	0.002457	0.002458	0.002593	0.001437	0.001501	0.001586
cobalt	0.000197	0.000197	0.000211	0.000264	0.000265	0.000319	0.000246	0.000246	0.000262
copper	0.000264	0.000266	0.000359	0.000486	0.000486	0.000590	0.000325	0.000705	0.000746
lead(b)	0.000241	0.000243	0.000305	0.000452	0.000452	0.000527	0.000282	0.000416	0.000441
manganese(b)	0.000479	0.000479	0.000530	0.000940	0.000940	0.001007	0.000542	0.000559	0.000602
mercury	0.000044	0.000054	0.000075	0.000078	0.000078	0.000099	0.000056	0.000215	0.000227
molybdenum	0.000359	0.000361	0.000459	0.000670	0.000671	0.000744	0.000433	0.000911	0.000964
nickel(b)	0.002744	0.002749	0.003013	0.004573	0.004574	0.005310	0.003769	0.003776	0.004359
selenium	0.000536	0.000536	0.000536	0.000869	0.000869	0.000870	0.000576	0.000576	0.000577
silver	0.000061	0.000061	0.000103	0.000137	0.000137	0.000191	0.000068	0.000068	0.000106
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000149	0.000149	0.000149	0.000255	0.000255	0.000255	0.000146	0.000146	0.000146
vanadium	0.005206	0.005214	0.005271	0.003878	0.003879	0.005810	0.007274	0.007275	0.007287
zinc	0.008948	0.009019	0.011717	0.018217	0.018231	0.020462	0.012093	0.024017	0.025431

Table 1.9-16 Comparison of the Existing and Approved Case, Project Case and Planned Development Case 1-Hour Trace Metal Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]
Peak 1-Hour [µg/m^3][(a)]									
aluminum	0.002792	0.002792	0.002951	0.003810	0.003810	0.004084	0.002790	0.002790	0.002956
antimony	0.000136	0.000136	0.000136	0.000167	0.000167	0.000167	0.000144	0.000144	0.000144
arsenic[(b)]	0.000081	0.000083	0.000090	0.000088	0.000089	0.000106	0.000126	0.000126	0.000127
barium	0.001706	0.001737	0.001632	0.001161	0.001545	0.001667	0.002657	0.002659	0.002659
beryllium	0.000005	0.000006	0.000006	0.000006	0.000006	0.000007	0.000007	0.000007	0.000007
cadmium	0.000467	0.000475	0.000656	0.000639	0.000639	0.000969	0.000664	0.000665	0.000727
chromium[(b)]	0.001381	0.001531	0.001627	0.001896	0.001897	0.001986	0.001399	0.001513	0.001595
cobalt	0.000224	0.000224	0.000246	0.000254	0.000254	0.000283	0.000233	0.000234	0.000255
copper	0.000347	0.000353	0.000382	0.000375	0.000376	0.000448	0.000515	0.000515	0.000518
lead[(b)]	0.000224	0.000268	0.000315	0.000345	0.000345	0.000399	0.000307	0.000307	0.000309
manganese[(b)]	0.000501	0.000542	0.000582	0.000719	0.000719	0.000768	0.000511	0.000542	0.000580
mercury	0.000100	0.000102	0.000096	0.000056	0.000091	0.000099	0.000157	0.000157	0.000157
molybdenum	0.000444	0.000466	0.000526	0.000515	0.000515	0.000558	0.000664	0.000665	0.000665
nickel[(b)]	0.003633	0.003642	0.004251	0.003960	0.003966	0.005046	0.003751	0.003758	0.004367
selenium	0.000563	0.000563	0.000564	0.000660	0.000660	0.000661	0.000553	0.000553	0.000554
silver	0.000062	0.000062	0.000090	0.000097	0.000097	0.000140	0.000065	0.000065	0.000094
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000148	0.000148	0.000148	0.000194	0.000194	0.000194	0.000152	0.000152	0.000152
vanadium	0.005434	0.005435	0.005427	0.005294	0.005294	0.005464	0.005610	0.005612	0.005620
zinc	0.011797	0.013086	0.014791	0.014473	0.014487	0.015861	0.017511	0.017523	0.017523

Table 1.9-16 Comparison of the Existing and Approved Case, Project Case and Planned Development Case 1-Hour Trace Metal Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]	Existing and Approved Case [µg/m³]	Project Case [µg/m³]	Planned Development Case [µg/m³]
Peak 1-Hour [µg/m³][(a)]						
aluminum	0.002613	0.002613	0.002729	0.002913	0.002913	0.003112
antimony	0.000132	0.000132	0.000132	0.000171	0.000171	0.000171
arsenic[(b)]	0.000065	0.000065	0.000123	0.000965	0.002638	0.002646
barium	0.001090	0.001200	0.002675	0.021227	0.058028	0.058199
beryllium	0.000005	0.000005	0.000007	0.000058	0.000158	0.000159
cadmium	0.000364	0.000364	0.000679	0.005308	0.014519	0.014562
chromium[(b)]	0.001455	0.001455	0.001509	0.006754	0.018467	0.018521
cobalt	0.000185	0.000186	0.000196	0.000405	0.001110	0.001114
copper	0.000260	0.000262	0.000520	0.004101	0.011213	0.011246
lead[(b)]	0.000232	0.000234	0.000306	0.002412	0.006597	0.006616
manganese[(b)]	0.000556	0.000556	0.000581	0.001833	0.005014	0.005029
mercury	0.000064	0.000071	0.000158	0.001254	0.003429	0.003439
molybdenum	0.000368	0.000368	0.000669	0.005307	0.014507	0.014550
nickel[(b)]	0.002908	0.002914	0.003243	0.010131	0.027795	0.027877
selenium	0.000778	0.000778	0.000779	0.000682	0.000682	0.000684
silver	0.000064	0.000064	0.000107	0.000077	0.000077	0.000110
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000181	0.000181	0.000181	0.000159	0.000159	0.000159
vanadium	0.004645	0.004645	0.004652	0.011096	0.030648	0.030738
zinc	0.008609	0.008685	0.017654	0.139910	0.382480	0.383610

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

(b) There are no 1-hour AAAQO for metal compounds except for arsenic (0.1 µg/m³), chromium (1 µg/m³), lead (1.5 µg/m³), manganese (2 µg/m³) and nickel (6 µg/m³).

Table 1.9-17 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Annual Trace Metal Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	Existing and Approved Case [μg/m^3]	Project Case [μg/m^3]	Planned Development Case [μg/m^3]	Existing and Approved Case [μg/m^3]	Project Case [μg/m^3]	Planned Development Case [μg/m^3]	Existing and Approved Case [μg/m^3]	Project Case [μg/m^3]	Planned Development Case [μg/m^3]
Peak Annual Average [μg/m^3][a]									
aluminum	0.000065	0.000065	0.000071	0.000095	0.000095	0.000105	0.000068	0.000068	0.000075
antimony	0.000002	0.000002	0.000002	0.000003	0.000003	0.000003	0.000002	0.000002	0.000002
arsenic[b]	0.000003	0.000003	0.000005	0.000004	0.000004	0.000006	0.000004	0.000008	0.000009
barium	0.000045	0.000057	0.000094	0.000059	0.000068	0.000114	0.000070	0.000157	0.000188
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001
cadmium	0.000019	0.000022	0.000036	0.000027	0.000029	0.000048	0.000026	0.000048	0.000061
chromium	0.000039	0.000043	0.000055	0.000055	0.000058	0.000074	0.000048	0.000076	0.000087
cobalt	0.000005	0.000006	0.000007	0.000008	0.000008	0.000011	0.000007	0.000008	0.000010
copper	0.000012	0.000014	0.000022	0.000017	0.000018	0.000028	0.000017	0.000034	0.000041
lead	0.000009	0.000011	0.000016	0.000013	0.000014	0.000021	0.000013	0.000023	0.000027
manganese[b]	0.000015	0.000016	0.000020	0.000022	0.000022	0.000028	0.000018	0.000025	0.000029
mercury	0.000002	0.000003	0.000005	0.000003	0.000004	0.000006	0.000004	0.000009	0.000011
molybdenum	0.000015	0.000018	0.000027	0.000020	0.000022	0.000034	0.000021	0.000043	0.000051
nickel[b]	0.000106	0.000111	0.000143	0.000145	0.000149	0.000206	0.000138	0.000179	0.000210
selenium	0.000011	0.000011	0.000011	0.000016	0.000016	0.000016	0.000012	0.000012	0.000012
silver	0.000002	0.000002	0.000003	0.000003	0.000003	0.000004	0.000002	0.000002	0.000003
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000003	0.000005	0.000005	0.000005	0.000003	0.000003	0.000003
vanadium	0.000114	0.000120	0.000165	0.000129	0.000133	0.000225	0.000174	0.000219	0.000266
zinc	0.000408	0.000484	0.000734	0.000547	0.000604	0.000916	0.000578	0.001146	0.001358

Table 1.9-17 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Annual Trace Metal Predictions at Selected Receptors (continued)

Parameter	**Hunter/Trapper A**			**Hunter/Trapper B**			**Operator's Residence**		
	Existing and Approved Case [µg/m^3]	**Project Case [µg/m^3]**	**Planned Development Case [µg/m^3]**	**Existing and Approved Case [µg/m^3]**	**Project Case [µg/m^3]**	**Planned Development Case [µg/m^3]**	**Existing and Approved Case [µg/m^3]**	**Project Case [µg/m^3]**	**Planned Development Case [µg/m^3]**
Peak Annual Average [µg/m^3](a)									
aluminum	0.000068	0.000068	0.000074	0.000083	0.000083	0.000091	0.000069	0.000069	0.000076
antimony	0.000002	0.000002	0.000002	0.000003	0.000003	0.000003	0.000002	0.000002	0.000002
arsenic(b)	0.000005	0.000006	0.000008	0.000004	0.000005	0.000007	0.000005	0.000006	0.000008
barium	0.000085	0.000110	0.000147	0.000058	0.000094	0.000140	0.000092	0.000120	0.000156
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
cadmium	0.000029	0.000036	0.000050	0.000024	0.000033	0.000051	0.000031	0.000039	0.000052
chromium	0.000053	0.000061	0.000074	0.000051	0.000062	0.000078	0.000056	0.000065	0.000077
cobalt	0.000007	0.000007	0.000009	0.000007	0.000008	0.000010	0.000007	0.000007	0.000009
copper	0.000020	0.000025	0.000033	0.000016	0.000023	0.000032	0.000022	0.000027	0.000035
lead	0.000014	0.000017	0.000022	0.000012	0.000016	0.000023	0.000015	0.000018	0.000023
manganese(b)	0.000019	0.000021	0.000025	0.000019	0.000023	0.000028	0.000020	0.000022	0.000026
mercury	0.000005	0.000006	0.000008	0.000003	0.000005	0.000008	0.000005	0.000007	0.000009
molybdenum	0.000025	0.000031	0.000041	0.000019	0.000028	0.000040	0.000027	0.000034	0.000043
nickel(b)	0.000137	0.000149	0.000183	0.000136	0.000153	0.000199	0.000142	0.000156	0.000190
selenium	0.000012	0.000012	0.000012	0.000014	0.000014	0.000015	0.000012	0.000012	0.000012
silver	0.000002	0.000002	0.000003	0.000003	0.000003	0.000004	0.000002	0.000002	0.000003
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004	0.000003	0.000003	0.000003
vanadium	0.000156	0.000169	0.000221	0.000135	0.000154	0.000225	0.000162	0.000177	0.000230
zinc	0.000672	0.000838	0.001089	0.000522	0.000760	0.001071	0.000724	0.000910	0.001152

Table 1.9-17 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Annual Trace Metal Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			Maximum Property Boundary		
	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]	Existing and Approved Case [µg/m^3]	Project Case [µg/m^3]	Planned Development Case [µg/m^3]
Peak Annual Average [µg/m^3](a)						
aluminum	0.000064	0.000064	0.000070	0.000077	0.000077	0.000084
antimony	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002
arsenic(b)	0.000003	0.000003	0.000005	0.000021	0.000035	0.000037
barium	0.000047	0.000059	0.000097	0.000453	0.000751	0.000798
beryllium	0.000000	0.000000	0.000000	0.000001	0.000002	0.000002
cadmium	0.000019	0.000023	0.000036	0.000122	0.000196	0.000213
chromium	0.000039	0.000043	0.000056	0.000172	0.000268	0.000284
cobalt	0.000006	0.000006	0.000007	0.000014	0.000020	0.000022
copper	0.000012	0.000015	0.000023	0.000091	0.000149	0.000159
lead	0.000010	0.000011	0.000016	0.000056	0.000090	0.000097
manganese(b)	0.000015	0.000016	0.000020	0.000052	0.000078	0.000083
mercury	0.000003	0.000003	0.000006	0.000027	0.000044	0.000047
molybdenum	0.000015	0.000018	0.000028	0.000117	0.000192	0.000204
nickel(b)	0.000107	0.000113	0.000145	0.000318	0.000458	0.000501
selenium	0.000011	0.000011	0.000011	0.000014	0.000017	0.000017
silver	0.000002	0.000002	0.000003	0.000002	0.000002	0.000003
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004
vanadium	0.000117	0.000123	0.000170	0.000351	0.000496	0.000558
zinc	0.000413	0.000499	0.000754	0.003107	0.005076	0.005392

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

(b) There are no annual AAAQO for metal compounds except for arsenic (0.01 µg/m^3), manganese (0.2 µg/m^3) and nickel (0.05 µg/m^3).

1.9.3.2 Transboundary Effects

There are no EAC, Project Case or PDC predicted concentrations above the respective AAAQOs or other applicable criteria at La Loche, Saskatchewan. The predictions at La Loche, Saskatchewan are presented with the selected receptors in Appendix 3-III.

1.9.3.3 Scientific Uncertainty

A discussion of the scientific uncertainty is presented in Appendix 3-II, Section 2.3.10.

1.9.4 Key Question AQPDC-2: What Effects Could the Project, the Existing and Approved Developments and Other Regional Developments Have on the Deposition of Acid-Forming Compounds in the Region?

1.9.4.1 Impact Analysis

The initial step in evaluating the effects of the PDC emissions on the deposition of acid-forming compounds is a review of the regional emissions of SO_2 and NO_X. Table 1.9-18 presents the emission rates of acid-forming compounds the RSA.

Table 1.9-18 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Acid Precursor Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Planned Development Case
SO_2 emissions [t/cd]	10.81	12.06	14.26
NO_X emissions [t/d]	26.52	36.14	54.45

Although the changes in regional emission rates give some indication of the impacts associated with the PDC, it is necessary to run a dispersion model to quantify the effect that these emissions will have on the deposition of acid-forming compounds in the region. The modelling includes background PAI values determined by AENV using the RELAD model (Cheng 2005, 2001), as discussed in Appendix 3-II.

Table 1.9-19 compares the EAC, Project Case and PDC maximum PAI predictions within the RSA and LSA (excluding the developed areas). The PDC emissions will result in increases in the areas predicted to experience deposition values in excess of 0.17, 0.25 and 0.50 keq/ha/yr.

Table 1.9-19 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Potential Acid Input Predictions

Descriptions	Existing and Approved Case[a]	Project Case[a]	Planned Development Case[a]
Local Study Area (LSA)			
maximum PAI [keq/ha/yr]	0.42	0.68	0.69
area >0.17 keq/ha/yr [ha]	21,521	43,491	80,740
area >0.25 keq/ha/yr [ha]	1,396	3,095	4,310
area >0.5 keq/ha/yr [ha]	0	31	38
area >1.0 keq/ha/yr [ha]	0	0	0
Regional Study Area (RSA)			
maximum PAI [keq/ha/yr]	0.42	0.68	0.69
area >0.17 keq/ha/yr [ha]	101,721	148,544	539,814
area >0.25 keq/ha/yr [ha]	1,396	3,103	9,520
area >0.5 keq/ha/yr [ha]	0	31	38
area >1.0 keq/ha/yr [ha]	0	0	0

[a] Excludes predictions within developed areas, which include the Project plant sites.

The CASA framework for managing acid deposition in Alberta considers management units represented by grid cells that are 1° by 1° in size. Table 1.9-20 presents PAI predictions for the 25 grid 1 by 1° cells that fall within the air modelling domain for the Project. The Project is located in grid cell 56°×111°. From the EAC to the PDC, the PAI levels within cell 56°×111° is expected to increase by 0.039 keq/ha/yr. Of the 25 grid cells listed, two were predicted to have PAI values in excess of the 0.25 keq/ha/yr critical load for sensitive ecosystems in the PDC. These two cells are located about 150 km NNW of the Project. In addition, the cell in which the Project is located is expected to have PAI levels above the 0.17 keq/ha/yr monitoring load.

Table 1.9-20 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Potential Acid Input Predictions for 1° by 1° Grid Cells

Grid Cell Centre[a]	Existing and Approved Case [keq/ha/yr]	Project Case [keq/ha/yr]	Planned Development Case [keq/ha/yr]
58°×113°	0.062	0.062	0.067
58°×112°	0.076	0.076	0.089
58°×111°	0.110	0.110	0.140

Table 1.9-20 Comparison of the Existing and Approved Case, Project Case and Planned Development Case Potential Acid Input Predictions for 1° by 1° Grid Cells (continued)

Grid Cell Centre(a)	Existing and Approved Case [keq/ha/yr]	Project Case [keq/ha/yr]	Planned Development Case [keq/ha/yr]
58°×110°	0.070	0.070	0.082
58°×109°	0.056	0.056	0.063
57°×113°	0.091	0.091	0.101
57°×112°	0.330	0.330	0.405
57°×111°	0.341	0.341	0.388
57°×110°	0.118	0.118	0.138
57°×109°	0.086	0.086	0.097
56°×113°	0.107	0.107	0.116
56°×112°	0.112	0.113	0.131
56°×111°(b)	0.161	0.165	0.200
56°×110°	0.127	0.130	0.149
56°×109°	0.101	0.102	0.112
55º×113º	0.132	0.132	0.136
55º×112º	0.128	0.129	0.134
55º×111º	0.158	0.160	0.169
55º×110º	0.153	0.155	0.162
55º×109º	0.102	0.103	0.109
54º×113º	0.167	0.167	0.168
54º×112º	0.151	0.151	0.153
54º×111º	0.102	0.102	0.104
54º×110º	0.097	0.098	0.100
54º×109º	0.085	0.086	0.088

(a) The 1° by 1° grid cells are centred on the listed latitude and longitude.

(b) The Project is located in the 56º×111º grid cell.

The PDC acid-precursor emissions are expected to increase the maximum predicted PAI levels as well as the spatial extents for each PAI threshold (i.e., 0.17, 0.25 and 0.5 keq/ha/yr). Several of the 1° by 1° grid cells have an increase in the maximum predicted PAI levels; however, only the 56°×111° grid cell will exceed the 0.17 keq/ha/yr threshold.

1.10 MONITORING

MEG is committed to ensuring regional air quality objectives are achieved through careful monitoring and regional management. MEG will monitor Project emission sources as required by the EPEA approval. In addition, MEG has applied to become a member of the following:

- Wood Buffalo Environmental Association (WBEA). The WBEA program includes strategies and plans for ambient air monitoring conducted in the region. These are reviewed on an ongoing basis by the WBEA to understand the need for program adjustments to assess the effects of new developments in the region.

- Cumulative Environmental Management Association (CEMA). The CEMA program is a forum for stakeholders to address cumulative effects of the regional development in north-eastern Alberta. The program provides the forum to discuss and make consensus-based decisions on the development and application of environmental management tools, thresholds, guidelines and objectives.

1.11 CONCLUSIONS

1.11.1 Introduction

The Project will release atmospheric emissions into the regional airshed. The air quality assessment considered how these emissions could affect local and regional air quality.

The air quality assessment of the Project included the evaluation of three distinct scenarios:

- The EAC includes an assessment of the cumulative air quality effects from the existing and approved industrial emission sources assuming full operation within the region, as well as estimated emissions from transportation and residential activities. The EAC represents the cumulative load on the airshed that can occur without additional regulatory approvals.
- The Project Case provides a cumulative assessment of the emissions from the Project in combination with EAC emissions in the region. The Project Case represents the load on the airshed once the Project is in operation.
- The PDC includes a cumulative assessment of the existing and approved projects in the region, the Project and other publicly disclosed regional emission sources. Since the PDC includes planned projects, none of which have received approval to operate and some of which have yet to apply for approval, the emissions used in the PDC are speculative and based on the information available at the time this document was prepared.

For each of the scenarios, the CALPUFF dispersion model was run in the dynamic 3-D mode to determine ground-level concentrations of the following:

- sulphur dioxide (SO_2);
- nitrogen dioxide (NO_2);
- carbon monoxide (CO);
- hydrogen sulphide (H_2S) and selected Total Reduced Sulphur (TRS) compounds;
- benzene and selected Volatile Organic Compounds (VOCs);
- fine particulate matter ($PM_{2.5}$);
- selected Polycyclic Aromatic Hydrocarbons (PAH) compounds; and
- selected trace metals.

In addition to the compounds listed above, the deposition of acid-forming compounds was considered. The emissions of both sulphur dioxide and oxides of nitrogen were used to predict PAI.

Concentrations of SO_2 and NO_2 and PAI levels were determined over the entire modelling domain, and the results were presented for both the RSA and LSA including and excluding developed areas. Concentrations of the above compounds (excluding PAI) were determined for the selected receptors. These receptors represent the primary population centres in or near the region that could potentially experience increased concentrations due to the Project. These include one community and two locations in Alberta that are of importance to First Nations groups. In addition, concentrations were predicted at two cabins, the Operator's Residence, the Christina Lake Lodge and along the Project property boundary where persons could experience prolonged exposure to air emissions. Concentrations were also predicted at La Loche, Saskatchewan to evaluate the transboundary effects of the Project emissions.

The CALPUFF model in 3-D mode was selected for use in assessing the air emissions from the Project since it has been deemed appropriate for use in the region by AENV and has been used in recent EIAs in the region.

The peak concentrations represent the highest 1-hour, 24-hour and annual predictions from the CALPUFF model. The maximum 1-hour values exclude the eight highest 1-hour predictions, as recommended by AENV (AENV 2003) for determining compliance with the AAAQOs. The peak predictions are presented for most compounds, with the exception of SO_2 and NO_2. The 1-hour maximum predictions are presented for SO_2 and NO_2 in the region and at the selected receptors.

The predicted concentrations and deposition values were compared to established AAAQOs or other criteria, as applicable. However, not all of the parameters have air quality objectives and standards against which the predicted concentrations could be evaluated. In such cases, the results of the modelling analyses were provided to other disciplines for evaluation. A summary of these evaluations has been presented in the Human Health Assessment (Section 3) and the Air Emissions Effects on Ecological Receptors section (Section 4). The predicted ambient ground-level concentrations for the Existing and Approved Case, Project Case and Planned Development Case are provided in detail in Appendix 3-III.

1.11.2 Regional Emission Sources

The Project is in an airshed that has numerous other sources of emissions. Despite the mitigation measures incorporated into the Project design, the air emissions may result in changes in the ambient air quality. Table 1.11-1 presents a summary of the emission rates of key air quality compounds in the RSA.

Table 1.11-1 Summary of Existing and Approved Case, Project Case and Planned Development Case Emissions in the Regional Study Area

Descriptions	Existing and Approved Case	Project Case	Planned Development Case	Change Due to Project [%][(a)]
SO_2 emissions [t/cd]	10.81	12.06	14.26	11.5
NO_X emissions [t/d]	26.52	36.14	54.45	36.2
CO emissions [t/d]	23.65	32.32	47.85	36.7
$PM_{2.5}$ emissions [t/d]	1.33	2.12	3.62	58.7
VOC emissions [t/d]	1.29	1.88	7.36	46.1
TRS emissions [t/d]	0.08	0.13	0.38	51.9

[(a)] Represents change between EAC and Project Case.

1.11.3 Existing and Approved Case

The EAC emissions in the RSA, as shown in Table 1.11-1, include a total of 10.81 t/cd (10.81 t/sd) of SO_2 emissions and 26.52 t/d of NO_X emissions. Within the modelling domain, the EAC includes a total of 271.30 t/cd (198.93 t/sd) of SO_2 emissions and 492.95 t/d of emissions of NO_X.

The modelling results for the EAC indicate the following:

- Regional Concentrations. The maximum predictions of 1-hour, 24-hour and annual ground-level SO_2 and NO_2 concentrations in the LSA and the RSA (outside of developed areas) are below the 1-hour, 24-hour and annual AAAQOs, as shown in Table 1.11-2.
- PAI Levels. PAI levels were predicted using the CALPUFF dispersion model in combination with background PAI values determined by AENV (Cheng 2001, 2005). The predictions indicate that areas above the 0.17 and 0.25 keq/ha/yr thresholds are possible within the RSA and LSA. In addition, twenty-five 1° by 1° grid cells, which are based on the CASA critical, target and monitoring loads framework and are in the air quality modelling domain, are all classified as being sensitive to acid deposition. The PAI levels were above 0.25 keq/ha/yr in the two grid cells where the majority of approved oil sands operations are located.

None of the remaining 23 grid cells had PAI levels above the 0.17 keq/ha/yr monitoring load.

- Selected Receptors. All predicted concentrations of SO_2, NO_2, CO, H_2S, COS, CS_2, benzene, select VOCs, $PM_{2.5}$, PAH compounds and select trace metals are below respective AAAQOs or other criteria, as applicable, at the selected receptors.
- Saskatchewan Receptor. All predicted concentrations of SO_2, NO_2, CO, H_2S, COS, CS_2, benzene, select VOCs, $PM_{2.5}$, PAH compounds and select trace metals are below respective AAAQOs or other criteria, as applicable, at La Loche, Saskatchewan.

Table 1.11-2 Summary of Regional Existing and Approved Case Sulphur Dioxide and Nitrogen Dioxide Predictions

Parameter	Maximum Concentration[(a)(b)] [µg/m³]	Number of Occurrences Above[(b)(c)] AAAQO	Area Above AAAQO[(b)(c)] [ha]
Local Study Area			
1-hour SO_2	283.1	0	0
24-hour SO_2	66.0	0	0
annual average SO_2	7.4	0	0
1-hour NO_2	87.9	0	0
24-hour NO_2	41.8	0	0
annual average NO_2	3.8	0	0
Regional Study Area			
1-hour SO_2	283.1	0	0
24-hour SO_2	66.0	0	0
annual average SO_2	7.4	0	0
1-hour NO_2	158.1	0	0
24-hour NO_2	65.6	0	0
annual average NO_2	5.5	0	0

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(b) All results exclude developed areas. Developed areas include the Project plant sites.

(c) The 1-hour, 24-hour and annual Alberta Ambient Air Quality Objectives for SO_2 are 450, 150 and 30 µg/m³, respectively. The 1-hour, 24-hour and annual Alberta Ambient Air Quality Objectives for NO_2 are 400, 200 and 60 µg/m³, respectively.

1.11.4 Project Case

The emission rates in the RSA associated with the Project Case are presented in Table 1.8-1. The Project is estimated to increase emissions in the RSA by 11.5% for calendar-day SO_2, 36.2% for NO_X, 36.7% for CO, 58.7% for $PM_{2.5}$, 46.1% for VOCs and 51.9% for TRS. The Project is estimated to increase emissions in the modelling domain by 0.5% for calendar-day SO_2, 1.9% for NO_X, 2.0% for CO, 2.5% for $PM_{2.5}$, 0.1% for VOCs and 0.6% for TRS.

The modelling results for the Project Case indicate the following:

- Regional Concentrations. The maximum predictions of 1-hour, 24-hour and annual ground-level SO_2 and NO_2 concentrations in the LSA and the RSA (outside of developed areas) are below the 1-hour, 24-hour and annual AAAQOs, as shown in Table 1.11-3.
- PAI levels. Because the PAI from the EAC already exceeds CASA PAI thresholds in the modelling domain, the SO_2 and NO_X emissions from the Project will result in an increase in the areas of PAI above 0.17 and 0.25 keq/ha/yr within both the RSA and the LSA. The 0.17 keq/ha/yr PAI isopleth is not predicted to extend into Saskatchewan. Emissions from the Project were predicted to increase PAI levels in eight of the twenty-five 1° by 1° grid cells in the modelling domain. No other grid cells, outside the two that were already exceeding the monitoring, target or critical loads in the EAC, are predicted. The grid cell in which the Project is located is centred on 56°×111° and the PAI level within this cell is expected to increase by 0.004 keq/ha/yr.
- Selected Receptors. The Project Case emissions will have a small incremental effect on the ambient ground-level concentrations at the selected receptors. Predicted concentrations of SO_2, NO_2, CO, H_2S, COS, CS_2, benzene, select VOC compounds, PAH compounds and select trace metals are below the respective AAAQOs or other criteria, as applicable. The predicted 24-hour $PM_{2.5}$ concentration is also below the AAAQO at all the selected receptors; however, the predicted peak 1-hour $PM_{2.5}$ concentration is above the AAAQO at the Maximum Property Boundary.
- Saskatchewan Receptor. Model predictions at La Loche, Saskatchewan show small increases in ambient concentrations (e.g., less than 1 $\mu g/m^3$ for SO_2 and NO_2); however, these concentrations are below respective AAAQOs or other criteria, as applicable.
- Greenhouse gases. The Project is estimated to provide maximum GHG emissions of 4,537 kt/y CO_2E.

Table 1.11-3 Summary of Regional Project Case Sulphur Dioxide and Nitrogen Dioxide Predictions

Parameter	Maximum Concentration[(a)(b)] [µg/m³]	Number of Occurrences Above AAAQO[(b)(c)]	Area Above AAAQO[(b)(c)] [ha]
LSA			
1-hour SO_2	416.1	0	0
24-hour SO_2	118.6	0	0
annual average SO_2	15.6	0	0
1-hour NO_2	161.4	0	0
24-hour NO_2	46.4	0	0
annual average NO_2	6.1	0	0
RSA			
1-hour SO_2	416.1	0	0
24-hour SO_2	118.6	0	0
annual average SO_2	15.6	0	0
1-hour NO_2	161.4	0	0
24-hour NO_2	65.7	0	0
annual average NO_2	6.1	0	0

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(b) All results exclude developed areas. Developed areas include the Project plant sites.

(c) The 1-hour, 24-hour and annual Alberta Ambient Air Quality Objectives for SO_2 are 450, 150 and 30 µg/m³, respectively. The 1-hour, 24-hour and annual Alberta Ambient Air Quality Objectives for NO_2 are 400, 200 and 60 µg/m³, respectively.

1.11.5 Planned Development Case

The emission rates associated with the PDC are presented in Table 1.11-1. The PDC emissions in the RSA are projected to increase by 31.9% for calendar-day SO_2, 105.3% for NO_X, 102.4% for CO, 171.5% for $PM_{2.5}$, 470.4% for VOCs and 357.4% for TRS compared to those in the EAC. The PDC emissions within the modelling domain are projected to increase by 14.3% for calendar-day SO_2, 32.9% for NO_X, 23.5% for CO, 29.5% for $PM_{2.5}$, 28.7% for VOCs and 20.9% for TRS compared with those in the EAC.

The modelling results for the PDC indicate the following:

- Regional Concentrations. The maximum predictions of ground-level SO_2 and NO_2 concentrations in the LSA and RSA (outside of developed areas) are below the 1-hour, 24-hour and annual AAAQOs, as shown in Table 1.11-4.

- PAI Levels. The predictions indicate that areas above the 0.17, 0.25 and 0.50 keq/ha/yr threshold are possible within both the RSA and LSA. The PDC PAI levels are above the 0.25 keq/ha/yr critical load for sensitive ecosystems in the two 1º by 1º grid cells where the majority of approved oil sands operations are located. In addition, the cell in which the Project is located is expected to have PAI levels above the 0.17 keq/ha/yr monitoring load. None of the remaining 22 grid cells had PAI levels above the 0.17 keq/ha/yr monitoring load.

- Selected Receptors. Predicted concentrations of SO_2, NO_2, CO, H_2S, COS, CS_2, benzene, select VOC compounds, PAH compounds and select trace metals are below the respective AAAQOs or other criteria, as applicable, at the selected receptors. The predicted 24-hour $PM_{2.5}$ concentration is also below the AAAQO at all the selected receptors; however, the predicted peak 1-hour $PM_{2.5}$ concentration is above the AAAQO at the Maximum Property Boundary.
- Saskatchewan Receptor. All predicted concentrations of SO_2, NO_2, CO, H_2S, COS, CS_2, benzene, select VOCs, $PM_{2.5}$, PAH compounds and select trace metals are below respective AAAQOs or other criteria, as applicable, at La Loche, Saskatchewan.

Table 1.11-4 Summary of Regional Planned Development Case Sulphur Dioxide and Nitrogen Dioxide Predictions

Parameter	Maximum Concentration[(a)(b)] [µg/m³]	Number of Occurrences Above AAAQO[(b)(c)]	Area Above AAAQO[(b)(c)] [ha]
LSA			
1-hour SO_2	416.3	0	0
24-hour SO_2	119.8	0	0
annual average SO_2	15.5	0	0
1-hour NO_2	161.4	0	0
24-hour NO_2	50.2	0	0
annual average NO_2	7.1	0	0
RSA			
1-hour SO_2	416.3	0	0
24-hour SO_2	119.8	0	0
annual average SO_2	15.5	0	0
1-hour NO_2	161.4	0	0
24-hour NO_2	67.8	0	0
annual average NO_2	7.1	0	0

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(b) All results exclude developed areas. Developed areas include the Project plant sites.

(c) The 1-hour, 24-hour and annual Alberta Ambient Air Quality Objectives for SO_2 are 450, 150 and 30 µg/m³, respectively. The 1-hour, 24-hour and annual Alberta Ambient Air Quality Objectives for NO_2 are 400, 200 and 60 µg/m³, respectively.

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2 NOISE ASSESSMENT

2.1 INTRODUCTION

MEG Energy Corp. (MEG) is a Calgary-based, privately held energy company focused on the development and recovery of bitumen, shallow gas reserves and the generation of power in northeast Alberta. MEG's Christina Lake Regional Project (CLRP) consists of 80 sections of oil sands leases within the Regional Municipality of Wood Buffalo (RMWB), approximately 15 km southeast of Secondary Highway 881 and 20 km northeast of Conklin.

MEG currently has approval to construct and operate the first two phases of the CLRP over 23 sections of land. In addition, MEG is developing a facility expansion (Phase 2B) to increase the production capacity of the Central Plant to 60,000 barrels per day (bpd). The Phase 2B plant will be located immediately adjacent to the existing Phase 1 and 2 processing facilities.

MEG is now proposing a further expansion of the CLRP to fully develop its Christina Lake oil sands leases. The Christina Lake Regional Project – Phase 3 (the Project) is an expansion of the current CLRP development area and will use Steam Assisted Gravity Drainage (SAGD) bitumen recovery technology. The Project will consist of two additional processing facilities (Plants 3A and 3B), 138 SAGD multi-well pads and associated steam generating equipment. Plant 3A will be located in the southeast corner of the lease (Sections 20 and 29-76-4 W4M) and Plant 3B will be located in the northwest end of the lease (Sections 32 and 33-77-6 W4M).

Construction of the Project is proposed to occur in two phases. Phase 3A is anticipated to begin construction in 2010, with initial steam injection in 2012. Phase 3B is anticipated to begin construction in 2012, with initial steam injection in 2014. The operational life of each plant is expected to be 25 years. Total production from the two new plants will produce an incremental 150,000 bpd of bitumen (approximately 23,800 cubic metres per day). It is anticipated that reclamation of the Project will be complete by 2044.

The objective of the noise assessment is to identify and analyze noise effects that result from sound emissions from the Project when added to existing noise levels. The assessment focused on the cumulative noise effects from the existing Central Plant and the proposed Plants 3A and 3B, associated wellpads and infrastructure.

Noise changes resulting from the Project are modelled and the effects are assessed to meet the requirements of the Terms of Reference (TOR) (AENV 2008) and requirements defined in Energy Resources Conservation Board (ERCB) Directive 038: Noise Control (Directive 038) (EUB 2007). The effects of noise on potentially affected people are assessed in Section 2.6.5. The effects of noise on wildlife are assessed in Volume 5, Section 6.3.2.

2.2 ASSESSMENT APPROACH

2.2.1 Noise Terminology

An introduction to the concepts and theories used in the assessment of outdoor acoustics is provided in Appendix 3-V. The key concepts and terms for noise evaluation include the following:

- "Sound" or "sound emissions" refer to the acoustic energy generated by natural or man-made sources, including Project activities.
- "Noise" or "noise levels" refer to the levels that can be heard or measured at a receptor.
- A noise "receptor" is a location where measurements or predictions of noise levels are made.
- The "volume" of a sound or noise is expressed on a logarithmic scale, in units called decibels (dB). Since the scale is logarithmic, a sound or noise that is perceived as twice as loud as another will only be three decibels (3 dB) higher. A sound or noise with double the number of decibels will be perceived as more than twice as loud. A three decibel (3 dB) change is also the average threshold at which the human ear can detect a change in volume.
- Outdoor noise is usually expressed as an "equivalent noise level" (L_{eq}), which is a logarithmic average of the measured or predicted noise levels over a given period of time. This type of average takes into account the natural variability of sound.
- Sound emissions and noise levels also have a "frequency". The human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while low and high frequencies are harder to hear. Environmental noise levels are usually presented as "A-weighted" decibels (or dBA), which incorporates the frequency response of the human ear.
- While low frequency noise may not be "heard", it can often be felt. A "C-weighted" decibel (or dBC) is a frequency-weighting in which the low frequencies are included more than with A weighting, making this unit useful in determining potential for low frequency noise impacts.

- Low Frequency Noise (LFN) is the portion of sound below a defined frequency spectrum band. As per ERCB Directive 038 (EUB 2007), LFN is defined as either a clear tone present below a frequency of 250 Hz or where the overall dBC minus dBA value exceeds 20 dB.
- "Sound power level (Lw)" is the level of sound power, expressed in decibel (dB) relative to a stated reference value of 10^{-12} watts.

2.2.2 Terms of Reference

The assessment was completed to meet the TOR (AENV 2008) for the Project (Table 2.2-1) which state the following:

Table 2.2-1 Terms of Reference Concordance Table

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
4.1.5 Modeling	[A] For each model used in the in the assessment scenarios, provide: (a) a justification for the model used. Air quality modeling should be conducted in accordance with the latest edition of the Air Quality Modeling Guidelines published by Alberta Environment; (b) a documentation of the assumptions used to obtain the modeling predictions; and (c) a discussion of the limitations of the models used and how these limitations were addressed, including sources of error and relative accuracy.	[A] Volume 3, Appendix 3-V Noise Modelling Methods
4.2 Climate, Air Quality and Noise		
4.2.1 Baseline Information	[B] Provide representative baseline noise levels at receptor location.	[B] Volume 3, Section 2.4.3 Existing and Approved Case Noise Levels
4.2.2 Impact Assessment	[C] Identify components of the Project that have the potential for creating increased noise levels and discuss the implications. Present the results of a noise assessment. Include:	[C] Volume 3, Section 2.6 Project Case Assessment
	(a) potentially-affected people and wildlife;	(a) Volume 3, Section 2.6.3 and 2.6.4 Project Case Noise Level Predictions and Low Frequency Noise Volume 3, Section 2.6.4 Project Case Assessment
	(b) an estimate of the potential for increased noise resulting from the development; and	(b) Volume 3, Section 2.6.5 Project Case Impact Assessment
4.2.2 Impact Assessment (continued)	(c) the implications of any increased noise levels.	(c) Volume 3, Section 2.6.3 to 2.6.5 Project Case Impact Assessment
	[D] Describe how air quality and noise impacts resulting from the Project will be mitigated.	[D] Volume 3, Section 2.3 Mitigation
	[E] Describe the residual air quality and noise effects of the Project and MEG's plans to manage those effects.	[E] Volume 3, Section 2.7 Monitoring

2.2.3 Assessment Cases

The assessment cases used for the Noise Assessment include an Existing and Approved Case (EAC), a Project Case and a Planned Development Case (PDC). The EAC includes those developments that already exist and those that have been approved but are not yet built. The Project Case includes existing and approved developments and the Project. The PDC considers developments that were publicly disclosed as of October 2007. The developments considered for each case in the assessment are listed in Table 2.2-1. All developments that have been considered in the assessment cases are shown in Volume 2, Section 5.

Noise can be considered a localized effect. Therefore, the assessment cases for noise focus on activities within a defined distance of the Project. For this assessment, the result is that there are a limited number of existing, approved or planned developments in the region that could affect noise levels in the Project area (Table 2.2-2). This, in turn, affects the level of detail in the assessment conducted for each case as listed in Table 2.2-2.

Although a PDC is presented, it is not assessed for noise. In addition to the lack of information available on planned projects, Directive 038 requirements state it is the responsibility of a proponent for any new project to ensure that the Directive criteria are met at potentially affected receptors. Once the criteria are set for a particular receptor, those criteria are to be met for all future applications that may affect that receptor.

Further detail is provided within the discussion of each assessment case.

Table 2.2-2 Developments Included in the Assessment Cases

Case	Developments Included in Assessment Cases	Extent of Discussion
Existing and Approved Case	• Phase 1 • Phase 2 • Phase 2B	• mandated ambient noise level for use in predictive modelling • predictive modelling from the developments in the existing and approved case • predicted noise levels are combined with the ERCB-mandated ambient noise level • noise from the Existing and Approved Case is determined for the study area and at specific residences that may be affected
Project Case	• Phase 1 • Phase 2 • Phase 2B • Phase 3	• mandated ambient noise level for use in predictive modelling • predictive modelling from the Project • predicted noise levels are combined with the ERCB-mandated ambient noise level • predicted noise levels are compared to measured ambient levels • noise from the Project is determined for the study area and at specific residences that may be affected
Planned Development Case	• Phase 1 • Phase 2 • Phase 2B • Phase 3 • major pipelines, utility corridors, roadways and others	• discussed qualitatively where information is available • assessment of planned developments is not required by ERCB

2.2.4 Key Question

The Project involves developing steam generation facilities and wellpads on MEG's lease, as well as additional processing facilities at the existing Central Plant. The proposed facilities and changes to the existing and approved facility are sufficient to potentially affect local noise levels.

In regards to noise, there is one key question for the Project:

NPC-1: What effects could activities associated with existing and approved developments and the Project have on local noise levels and nearby dwellings?

2.2.5 Temporal Considerations

The noise assessment for the Project evaluated the potential noise levels over the life of the Project by considering a typical operating condition consisting of the following:

- Phase 1 facilities;
- Phase 2 facilities;
- Phase 2B facilities;

- Phase 3 facilities; and
- all associated wellpads and pump stations.

This represents the highest expected continuous noise levels over the life of the Project.

2.2.6 Spatial Considerations

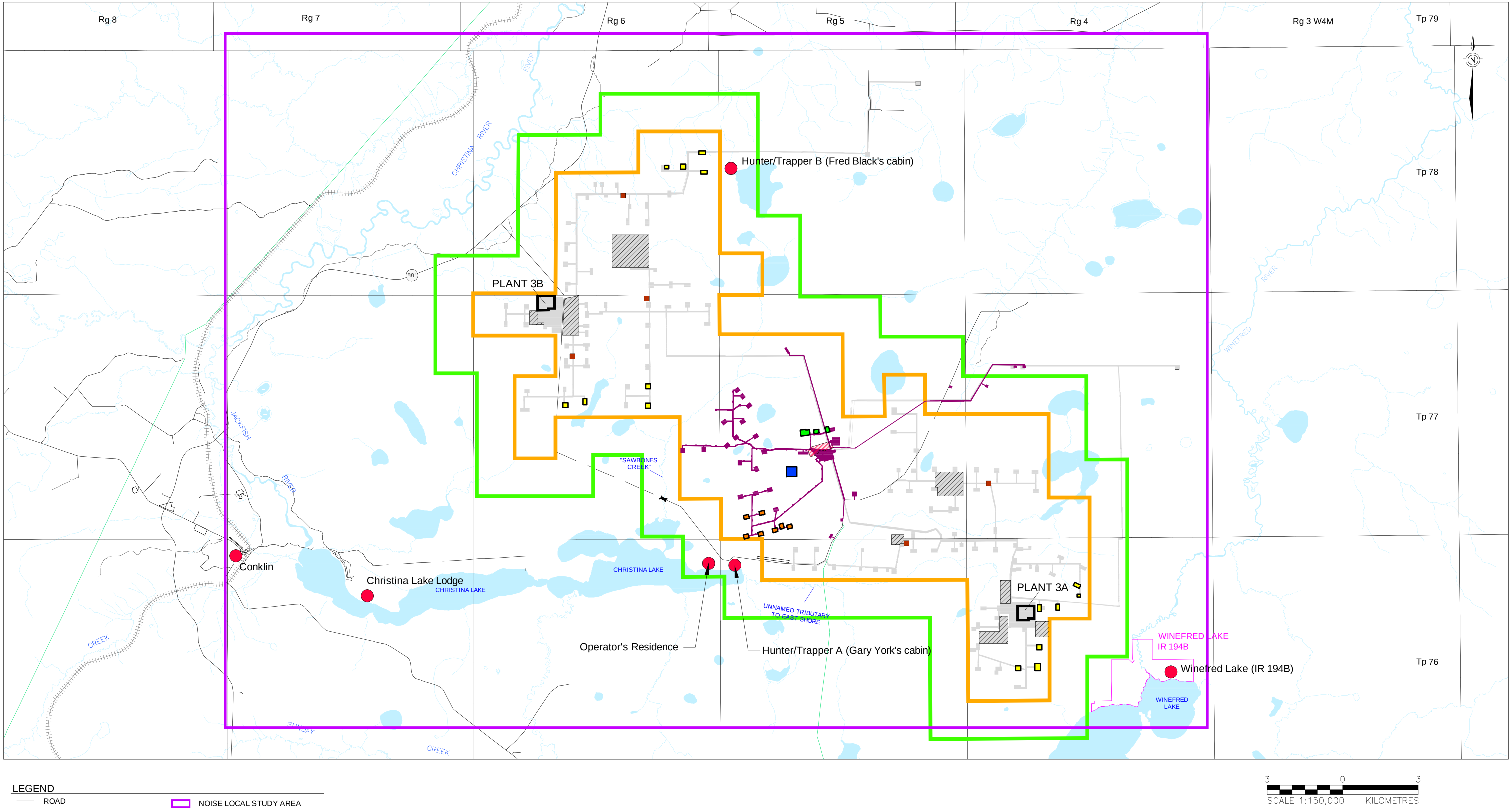
The assessment and regulation of noise from energy projects in Alberta is the responsibility of the ERCB, which regulates noise from a receptor perspective. Noise-sensitive receptors are considered to be any permanent residences or seasonally occupied dwellings used at least six weeks out of the year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

For the assessment of the noise resulting from the Project, six noise receptors were considered. Location details are provided in Table 2.2-3.

Table 2.2-3 Location of Receptors Included in the Noise Assessment

Location	Easting [m]	Northing [m]
Conklin	494494	6164871
Winefred Lake (IR 194B)	531603	6160262
Hunter/Trapper Cabin A (Gary York's cabin)	514296	6164497
Hunter/Trapper Cabin B (Fred Black's cabin)	514145	6180245
Operator's Residence	513258	6164571
Christina Lake Lodge	499711	6163283

In addition to the discrete noise receptors identified in the Table 2.2-3, noise levels were also determined over a Local Study Area (LSA) for each location assessed. Using the remote area 1.5 km criteria established in Directive 038, a Local Study Area (LSA) was defined to assess the propagation of noise from the Project. The noise LSA boundary for this Project is defined by a rectangle 39 by 28 km in size. The LSA was chosen to encompass all potential noise effects of the Project. It encompasses the noise-sensitive receptors, the Project area and the ERCB 1.5 km criteria boundary. The ERCB 1.5 km criteria boundary is measured 1.5 km from the Project area boundary. The noise-sensitive receptors, potential receptors, Project area, 1.5 km ERCB criteria boundary and LSA used for the Project are shown in Figure 2.2-1. A Regional Study Area (RSA) is not defined for noise since noise attenuates with distance and it is expected to attenuate to background level within the defined LSA.



LEGEND

—	ROAD
┼┼┼┼	RAILWAY
—	RIVER
—	PIPELINE
▭	OPEN WATER
▭	INDIAN RESERVE
▭	MEG LEASE BOUNDARY
▭	1.5 km FROM LEASE BOUNDARY
▨	CENTRAL PLANT
▭	NOISE LOCAL STUDY AREA
■	PHASE 3 PUMP STATION
■	PHASE 1 MODELLED WELLPAD
■	PHASE 2 MODELLED WELLPAD
■	PHASE 2B MODELLED WELLPAD
■	PHASE 3 MODELLED WELLPAD
●	RECEPTOR LOCATION
■	EXISTING AND APPROVED DEVELOPMENT
■	PROJECT FOOTPRINTS
▨	BORROW AREAS

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

NOISE LOCAL STUDY AREA AND RECEPTOR LOCATIONS

MEG ENERGY CORP.

PROJ	07–1346–0009.8100		FILE No.	Noise receptors
DESIGN	JC	07/11/07	SCALE AS SHOWN	REV. 0
CADD	TRE	12/03/08		
CHECK	TD	17/03/08		
REVIEW	IGG	18/03/08		

FIGURE: 2.2-1

L:\2007\1346 Oil Sands\07–1346–0009–MEG EXPANSION\8100\8150\Fig 2.2–1 Noise receptors and LSA.dwg Mar 25, 2008 – 1:23pm

2.2.7 Noise Criteria

The ERCB requirements for the control of noise from energy projects are the most stringent environmental noise criteria in Alberta. Directive 038 outlines acceptable noise levels and provides details for assessing noise impacts. A key aspect of Directive 038 is that the noise is viewed from the perspective of receptors, rather than considering sound levels at the property line.

The directive requires that noise from energy-related facilities be controlled to a Permissible Sound Level (PSL) at any noise-sensitive receptor (defined as permanent residences or seasonally occupied dwellings) within 1.5 km of the Project area boundary. In addition, there is a requirement for facilities to meet criteria at 1.5 km distance from the Project area boundary in the absence of any receptor. Therefore, the PSL was established at receptors located within 1.5 km of the Project area boundary.

To establish the specific criteria for this assessment, a PSL must be established at each key receptor selected for the Project. The PSL is defined as the maximum sound level that a facility may not exceed at a point 15 m from the nearest or most impacted residence.

The Directive 038 PSL is calculated using a Basic Sound Level (BSL) derived from the population density and proximity to travelled roadways. The BSL is then adjusted for:

- the time of day, to account for the nature of the activity;
- the actual ambient sound level in the area, if there is no existing energy-related activity; and
- responses to temporary activities.

Table 2.2-4 summarizes the applicable daytime and nighttime PSL at the 1.5 km criteria boundary and noise receptor locations evaluated in the assessment. Daytime is the period from 7:00 a.m. to 10:00 p.m. and nighttime is the period from 10:00 p.m. to 7:00 a.m. Details on the PSL calculation for the noise-sensitive receptors are provided in the noise modelling appendix (Appendix 3-V).

Table 2.2-4 Permissible Sound Level for Local Noise Receptors

Noise Receptor	Permissible Sound Levels [dBA][(a)]	
	Daytime PSL	Nighttime PSL
Conklin	53	43
Winefred Lake (IR 194B)	50	40
Hunter/Trapper Cabin A (Gary York's cabin)	50	40
Hunter/Trapper Cabin B (Fred Black's cabin)	50	40
Operator's Residence	50	40
Christina Lake Lodge	50	40
1.5 km Criteria Boundary	50	40

(a) The PSL values were determined in accordance with Directive 038 (EUB 2007).

In addition, Directive 038 requires that LFN effects be considered. For LFN within the LSA, the difference between C-weighted and A-weighted noise generated by the Project was compared to the 20 dBA guidance set out in Directive 038 (EUB 2007).

2.2.8 Impact Criteria and Classification

The impact assessment methods used for the Project have been described in detail in Volume 2, Section 4 and involve the evaluation of residual impacts. The residual impacts for noise were classified using quantification criteria to determine environmental consequence. Each impact is first described in terms of the following criteria: direction, magnitude, geographic extent, duration, reversibility and frequency (including seasonal effects).

Table 2.2-5 details the impact description criteria for the noise component of the Environmental Impact Assessment (EIA). Criteria for direction, reversibility, duration and frequency are the same for all environmental components, and are described in detail in Volume 2, Section 4.8. Two criteria rankings are unique to the noise assessment, geographic extent and magnitude, as described below.

The geographic extent was classified as either local or regional. Local effects are defined by a 39 by 28 km area, which covers seven local noise receptors and the 1.5 km area from the operational boundary. Effects further than the LSA are defined as regional. The 1.5 km threshold was selected based on the ERCB criteria of 40 dBA at 1.5 km from a facility (EUB 2007). See Section 2.2.6 for further definition and geographic extent of impact assessment.

Table 2.2-5 Impact Description Criteria and Numerical Scores for Noise

Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]	Reversibility[e]	Frequency[f]
positive: a decrease in noise levels **neutral:** no change in noise levels **negative**: an increase in noise levels	**negligible** (0) **low** (+5) **moderate** (+10) **high** (+15) magnitudes are detailed in Table 2.2-5	**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

[a] Direction: positive or negative effect of measurement endpoints, as defined for the specific component.

[b] Magnitude: degree of change to analysis endpoint.

[c] Geographic Extent: areas that are affected by the impact.

[d] Duration: length of time over which the environmental effect occurs.

[e] Reversibility: whether the effect on the resource (or resource capability) can or cannot be reversed.

[f] Frequency: how often the environmental effect occurs.

Table 2.2-6 details the magnitudes used for the impact assessment. The approach used to establish the magnitude classification considers the ERCB criteria and the threshold at which people will begin to notice a change in noise levels (3 dBA). The impact description criteria table (Table 2.2-5) also provides numerical scores that are used to determine environmental consequence, as described in Volume 2, Section 4.8.

Table 2.2-6 Magnitude Classifications for Noise

Receptor	Magnitude of Maximum Noise Level [dBA] is:			
	Negligible[a]	Low	Moderate	High
Conklin	<41 dBA	≤43	>43	>53
All other noise receptors	<38 dBA	≤40	>40	>50

[a] Based on an ambient baseline level of 38 dBA at Conklin and 35 dBA at all other receptors, plus the 3 dBA threshold for noticing change in noise levels.

2.2.9 Assessment Methods

The TOR specifies that the noise assessment must meet the requirements that are set out in Directive 038, which emphasizes the changes due to the Project alone.

The assessment is focused on predicting the change in noise due to the Project operations. In addition, the assessment analyzes the cumulative effects that will result when these predicted levels are added to existing noise levels. Since the noise experienced at a given location due to Project operations will vary as activities move over time, this assessment has focused on the periods of the Project operations that have the greatest potential to affect key receptors.

The assessment of noise for the Project was completed by:

- establishing the existing and approved noise levels at the selected receptors; and
- predicting noise levels at the receptors and over the LSA due to the proposed Project activities within the Project boundary.

Based on the nature of sound and past experience with similar projects, noise from industrial projects will typically attenuate to below background noise levels within 5 km of an activity (EnCana 2007). Since there are no other existing energy-related developments within 5 km of Project activities, noise from other existing, approved and planned developments was not considered. The closest development is the EnCana FCCL Oil Sands Ltd. (EnCana) Christina Lake Thermal Project located about 12 km southwest of the Plant 3B.

The Project Case includes all operations proposed as part of the Project. One of the most important factors affecting noise levels is proximity of activities to the receptors. As a result, the noise assessment of the Project is focused on Plant 3A and 3B and all operating wellpads and infrastructure within the Project area boundary. More detail on the assessment methods is provided in Appendix 3-V.

2.2.10 Noise Modelling Approach

The following is a brief summary of the noise modelling methods used for this assessment. A detailed description of the selected methods and limitations can be found in Appendix 3-V.

Predictive modelling of noise was done using the Computer Aided Noise Attenuation (CadnaA) model, which is based on internationally accepted algorithms for calculating outdoor noise propagation. The model scenario was established to calculate the Project operations assuming the proposed facilities were operating at full capacity. This approach provided a “realistic worst case” of noise level contributions from the Project. Other approved developments in the region are more than 12 km away from the Project activities and therefore are not expected to affect noise levels at the selected receptor; therefore, these sources were not included in the noise predictions.

2.3 MITIGATION

Several facility design features for the Project will provide noise mitigation and have been considered in the noise assessment of the Project Case. These measures include the following:

- building attenuation, where components of the processing equipment are housed in buildings;
- building and tanks are included in the acoustic model as structural barrier; and
- some fixed equipment with manufacturer-provided noise ratings have noise control incorporated to meet *Alberta Occupational Health and Safety Act* (OHSA) design requirements.

2.4 EXISTING AND APPROVED CASE

A review of activities near the Project indicated there are no existing and approved developments that could affect noise levels at the 1.5 km ERCB criteria boundary or at the identified receptors. The nearest energy-related development to the Project is the Christina Lake Thermal Project, which is about 12 km from the Plant Facility 3B. At this distance, the EnCana project will not affect noise levels within the Project area boundaries or at the 1.5 km criteria boundary for the Project. Any contributions to cumulative effects at distant receptors, including Conklin, Winefred Lake and Christina Lake Lodge, are expected to be well below ambient levels. Therefore the EAC focused on the CLRP Phases 1, 2 and 2B noise emissions using ERCB assessment methodology.

2.4.1 Ambient Noise Levels

Based on research conducted by the Environment Council of Alberta, the average rural ambient sound level in Alberta is about 35 dBA L_{eq} at night (EUB 2007). The average rural ambient nighttime sound level of 35 dBA is considered representative of the nighttime ambient sound level at the noise receptors. This ambient sound level, as mandated by Directive 038, was combined with the predicted noise contributions from Phase 1, 2 and 2B operation to establish the EAC sound level. Similarly, the average rural ambient sound level of 35 dBA will be used to represent the lowest background noise levels at the 1.5 km from Project area boundary limit in this assessment.

Based on Directive 038 requirements, the population density at Conklin will result in an ambient level of 38 dBA (EUB 2007).

2.4.2 Noise Emissions

A predictive noise model was used to determine noise levels at the identified receptors and to map noise levels from the existing and approved operation. Noise sources for the CLRP were entered into the model based on standard equipment operating parameters supplied by MEG. This is the worst-case scenario for the normal operation life of the CLRP as the sound emissions were considered to be constant, or operating on a continuous basis.

Noise emissions for Phases 1, 2 and 2B were established using the following:

- client-supplied project equipment lists, design data and equipment noise rating;
- field measurement of the same or similar equipment;
- referenced publications listing noise outputs for the same or similar equipment; and
- equipment specification and referenced formulae from acoustic literature such as Beranek and Ver (1992) and Bies and Hansen (2003) to estimate emissions.

Project design data were used to establish if equipment will be enclosed in buildings or if noise controls will already be in place (e.g., silencers). The assessment focused on equipment that would be considered a major noise emitter on the site.

In the case of indoor noise sources, the sound transmission loss of the building envelope has been considered in the overall sound power level of the building. All pump units under the rated power of 10 kW are considered to have negligible noise emission levels. They are not included in the EAC assessment. Spectral data for each building and outdoor noise sources are found in Appendix 3-V.

Existing mitigation features in use at the Central Plant were included in the predictive modelling for the EAC. These mitigation measures include the following:

- building attenuation where components of the processing equipment are housed in buildings;
- buildings and tanks are included in the acoustic model as structural barriers; and

- some fixed equipment with manufacturer-provided noise ratings have noise control incorporated to meet *Alberta Occupational Health and Safety Act* (OHSA) design requirements.

2.4.2.1 Phase 1

Tables 2.4-1 to 2.4-6 list the equipment within each building associated with Phase 1 and the corresponding noise emission levels per building. Table 2.4-7 shows the noise emission level of outdoor noise sources associated with Phase 1 used in the assessment.

Table 2.4-1 Phase 1 Process Building (1-BU-191) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
1P403A/B	Diluent Pump	2
1PM403A/B	Diluent Pump Motor	2
1P415	Slop Oil Demulsifier Injection Pump	1
1P501A/B	Reverse Demulsifier Injection Pump	2
Process Building (1-BU-191) total indoor sound power level of 115 dBA		

Table 2.4-2 Phase 1 De-Oiling Building (1-BU-192) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
1P120	Disposal Water Tank Feed Pump	1
1PM120	Disposal Water Tank Feed Pump Motor	1
De-Oiling Building (1-BU-192) total indoor sound power level of 110 dBA		

Table 2.4-3 Phase 1 Water Treatment Building (1-BU-291) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
1P202A/B	Raw Water Pump	2
1PM202A/B	Raw Water Pump Motor	2
1P205A/B	Backwash Pump	2
1PM205A/B	Backwash Pump Motor	2
1P263A/B	Regen Dilution Water Pump	2
1PM263A/B	Regen Dilution Water Pump Motor	2
1P301A/B	Low Pressure Boiler Feed Water Pump	2
1PM301A/B	Low Pressure Boiler Feed Water Pump Motor	2
Water Treatment Building (1-BU-291) total indoor sound power level of 119 dBA		

Table 2.4-4 Phase 1 Steam Generation Building (1-BU-391) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
1P304A/B	High Pressure Boiler Feed Water Pump	2
1PM304A/B	High Pressure Boiler Feed Water Pump Motor	2
1K310	Combustion Air Blower	1
1KM310	Combustion Air Blower Motor	1
1K571A/B	Plant Instrument Air Compressor	2
1KM571A/B	Plant Instrument Air Compressor Motor	2
1B305	Steam Generator	1
Steam Generation Building (1-BU-391) total indoor sound power level of 120 dBA		

Table 2.4-5 Phase 1 Disposal Building (1-BU-491) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
1P123A/B	Produced Water Booster Pump	2
1PM123A/B	Produced Water Booster Pump Motor	2
1P125A/B/C	Produced Water Disposal Pump	3
1PM125A/B/C	Produced Water Disposal Pump Motor	3
1P403A/B	Diluent Pump	2
1PM403A/M	Diluent Pump Motor	2
Disposal Building (1-BU-491) total indoor sound power level of 118 dBA		

Table 2.4-6 Phase 1 Glycol Building (1-BU-551) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
1P513A/B	Glycol Circulation Pump	2
1PM513A/B	Glycol Circulation Pump Motor	2
1P516	Glycol Make-up Pump	1
1PM516	Glycol Make-up Pump Motor	1
Glycol Building (1-BU-551) total indoor sound power level of 115 dBA		

Table 2.4-7 Phase 1 Outdoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity	Sound Level at 1 m [dBA]	Sound Power [dBA]
1B305	Steam Generator Stack	1	n/a	89
1EA510	Glycol Cooler	1	85	n/a
1H511	Glycol Heater	1	85	n/a
K041 & KM041	Wellpad ‘A’ Instrument Air Compressor Building	1	n/a	80
1AHU2910	Building 1-BU-291 Air Handling Unit and Motor	1	n/a	97
1P116A/B 1PM116	Induced Gas Flotation Eductor Pump and Motor	2	n/a	98

n/a = Not applicable.

2.4.2.2 Phase 2

Tables 2.4-8 to 2.4-19 list the equipment within each building associated with the Phase 2 operations and the corresponding noise emission levels per building. Table 2.4-20 shows the noise emission level of outdoor noise sources associated with Phase 2 operation used in the assessment.

Table 2.4-8 Phase 2 Process Building (2-BU-190) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P110A/B/C	Sales Oil Transfer Pump	3
2PM110A/B/C	Sales Oil Transfer Pump Motor	3
2P525	Recovered Diluent Pump	1
2PM525	Recovered Diluent Pump Motor	1
Process Building (2-BU-190) total indoor sound power level of 112 dBA		

Table 2.4-9 Phase 2 De-Oiling Building (2-BU-192) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P117A/B	Induced Gas Flotation Froth Pump	2
2PM117A/B	Induced Gas Flotation Froth Pump Motor	2
2P119	Skim Oil Pump	1
2PM119	Skim Oil Pump Motor	1
2P120A/B	Produced Water Transfer Pump	2
2PM120A/B	Produced Water Transfer Pump Motor	2
2P135A/B	Hot Lime Softening Feed Pump	2
2P135A/B	Hot Lime Softening Feed Pump Motor	2
2P406A/B	Off-Spec Pump	2
2P406A/B	Off-Spec Pump Motor	2
De-oiling Building (2-BU-192) total indoor sound power level of 116 dBA		

Table 2.4-10 Phase 2 Oil Removal Facility Building (2-BU-194) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2MXM136A/B	Oil Removal Facility Vessel Agitator Motor	2
Oil Removal Facility Building (2-BU-194) total indoor sound power level of 112 dBA		

Table 2.4-11 Phase 2 Water Treatment Building (2-BU-290) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P205A/B	Hot Lime Softening Recirculation Pump	2
2PM205A/B	Hot Lime Softening Recirculation Pump Motor	2
2P206A/B	After Filter Backwash Pump	2
2PM206A/B	After Filter Backwash Pump Motor	2
2P209A/B	Soft Acid Caption/Weak Acid Caption Feed Pump	2
2PM209A/B	Soft Acid Caption/Weak Acid Caption Feed Pump Motor	2
2P218A/B	Dilution/Service Pump	2
2PM218A/B	Dilution/Service Pump Motor	2
2P301A/B/C	Low Pressure Boiler Feed Water Pump	3
2PM301A/B/C	Low Pressure Boiler Feed Water Pump Motor	3
2P551A/B	Utility Water Pump	2
2PM551A/B	Utility Water Pump Motor	2
2AHM2901	Water Treatment Building Air Handling Unit Motor	1
Water Treatment Building (2-BU-290) total indoor sound power level of 117 dBA		

Table 2.4-12 Phase 2 Steam Generation Building (2-BU-390) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2PK330	Steam Generator Package	1
2K309	Air Make-Up Unit Blower, Steam Generation Building	1
2KM309	Air Make-Up Unit Blower Motor, Steam Generation Building	1
2K310	Combustion Air Blower	1
2K310	Combustion Air Blower Motor	1
Steam Generation Building (2-BU-390) total indoor sound power level of 118 dBA		

Table 2.4-13 Phase 2 Co-Generation Building (2-BU-393) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P304A/B/C	High Pressure Boiler Feed Water Pump	3
2PM304A/B/C	High Pressure Boiler Feed Water Pump Motor	3
2K353A/B	Scanner Cooling Air Blower	2
2KM353A/B	Scanner Cooling Air Blower Motor	2
2P3172A/B	Gas Turbine/Generator Lube Oil Aerial Circulation Package Pump	2
2PM3172A/B	Gas Turbine/Generator Lube Oil Aerial Circulation Package Pump Motor	2
2EAM3174A/B	Gas Turbine/Generator Lube Oil Aerial Cooler Motor	2
2EAM3175A/B	Gas Turbine/Generator Lube Oil Aerial Cooler Motor	2
2P3205	Gas Turbine Wash Water RO Feed Pump	2
PK314	Gas Turbine/Generator Package	1
Co-Generation Building (2-BU-393) total indoor sound power level of 121 dBA		

Table 2.4-14 Phase 2 Diluent Pump Building (2-BU-490) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P403A/B	Diluent Pump	2
2PM403A/B	Diluent Pump Motor	2
Diluent Pump Building (2-BU-490) total indoor sound power level of 109 dBA		

Table 2.4-15 Phase 2 Slop Treater Building (2-BU-493) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P411	Slop Treater Pump	1
2PM411	Slop Treater Pump Motor	1
Slop Treater Building (2-BU-493) total indoor sound power level of 106 dBA		

Table 2.4-16 Phase 2 Glycol Utility Building (2-BU-553) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2K571A/B	Plant Instrument Air Compressor	2
2KM571A/B	Plant Instrument Air Compressor Motor	2
Glycol Utility Building (2-BU-553) total indoor sound power level of 103 dBA		

Table 2.4-17 Phase 2 Vapour Recovery Unit Building (2-BU-555) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2K593	Vapour Recovery Unit 1st Stage Compressor	1
2KM593	Vapour Recovery Unit Compressor Motor	1
2K593	Vapour Recovery Unit 2nd Stage Compressor	1
2KM593	Vapour Recovery Unit 2nd Stage Compressor Motor	1
Vapour Recovery Unit Building (2-BU-555) total indoor sound power level of 111 dBA		

Table 2.4-18 Phase 2 Lift Gas Compressor Building (2-BU-557) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2K582A/B	Lift Gas Compressor	2
2KM582A/B	Lift Gas Compressor Motor	2
Lift Gas Compressor Building (2-BU-557) total indoor sound power level of 113 dBA		

Table 2.4-19 Phase 2 Potable Water Building (2-BU-567) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2P569	Nanofilter Feed Pump	1
2PM569	Nanofilter Feed Pump Motor	1
2P5693	Nanofiltration System Booster Pump	1
2PM5693	Nanofiltration System Booster Pump Motor	1
2P5694	Clean In Place (CIP) Pump	1
2PM5694	Clean In Place (CIP) Pump Motor	1
Potable Water Building (2-BU-567) total indoor sound power level of 115 dBA		

Table 2.4-20 Phase 2 Outdoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity	Sound Level at 1 m [dBA]	Sound Power [dBA]
2B305	Steam Generator Stack	1	n/a	90
2PK310	Gas Turbine Exhaust Stack	1	n/a	94
2PK350	Heat Recovery Steam Generator	1	n/a	97
2PK310	Gas Turbine Air Inlet	1	n/a	97
2P116A/B 2PM116	Induced Gas Flotation Eductor Pump and Motor	2	n/a	98
2EA510	Glycol Cooler	1	85	n/a
2PK518	Glycol Heater	1	85	n/a
2K041 & 2KM041	Wellpad ‘B-E’ Instrument Air Compressor Building	4	n/a	64
2AHU2001	Air Handling Unit and Motor for 2-BU-290	1	n/a	97
2PK360	Air Make-up Unit for 2-BU-390	1	n/a	97
2PK590	Vapour Recovery Unit package	1	n/a	96

n/a = Not applicable.

2.4.2.3 Phase 2B

Tables 2.4-21 to 2.4-28 list the equipment within each building associated with Phase 2B and the corresponding noise emission levels per building. Table 2.4-29 shows the noise emission level of outdoor noise sources associated with Phase 2B used in the assessment.

Table 2.4-21 Phase 2B Process Building (2B-BU-190) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-P202A/B	Raw Water Pump/Motor	2
2B-P116	Induced Gas Flotation Eductor Pump/Motor	1
2B-P117A/B	Induced Gas Flotation Froth Pump/Motor	2
2B-P119	Skim Oil Pump/Motor	1
2B-P120	Produced Water Transfer Pump/Motor	1
2B-P121	De-Sand Pump/Motor	1
2B-P135A/B	Hot Lime Softening Feed Pump/Motor	2
2B-P250	Deoiling Polymer Injection Pump/Motor	1
2B-P406A/B	Off-Spec Pump/Motor	2
2B-P501	Reverse Demulsifier Injection Pump/Motor	1
2B-P503	Demulsifier Injection Pump/Motor	1
2B-P525	Recovered Diluent Pump/Motor	1
2B-P532A/B	High Pressure Flare Knock Out Pump/Motor	2
2B-202A/B	Raw Water Pump/Motor	2
Process Building (2B-BU-190) total indoor sound power level of 118 dBA		

Table 2.4-22 Phase 2B Water Treatment Building (2B-BU-290) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-P204	Dirty Backwash Transfer Pump/Motor	1
2B-P205	Hot Lime Softening Recirculation Pump/Motor	1
2B-P206A/B	After Filter Backwash Pump/Motor	2
2B-P209	After Filter Feed Pumps/Motor	1
2B-P217A/B	Neutralization Pump/Motor	2
2B-P218A/B	Dilution/Service Pump/Motor	2
2B-P227	Magox Slurry Pump/Motor	1
2B-P228	Lime Slurry Pump/Motor	1
2B-P244	Flocculent Pump/Motor	1
2B-P261	Caustic Pump/Motor	1
2B-P263	Acid Dosing Pump/Motor	1
2B-P267	Hot Lime Softening Sludge Sampling Pump/Motor	1
2B-P301A/B	Low Pressure Boiler Feed Water Pump/Motor	2
2B-P507	O_2 Scavenger Injection Pump/Motor	1
2B-P551A/B	Utility Water Pump/Motor	2
Water Treatment Building (2B-BU-290) total indoor sound power level of 119 dBA		

Table 2.4-23 Phase 2B Steam Generation Building (2B-BU-390) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-PK330	Steam Generator Package	1
2B-P330A/B	High Pressure Boiler Feed Water Pump	2
2B-PM304A/B	High Pressure Boiler Feed Water Pump Motor	2
2B-K310	Combustion Air Blower	1
2B-KM310	Combustion Air Blower Motor	1
2B-K571	Plant Instrument Air Compressor	1
2B-KM571	Plant Instrument Air Compressor Motor	1
Steam Generation Building (2B-BU-390) total indoor sound power level of 126 dBA		

Table 2.4-24 Phase 2B Co-Generation Building (2B-BU-393) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-K353A/B	Scanner Cooling Air Blower	2
2B-KM353A/B	Scanner Cooling Air Blower Motor	2
2B-P3172A/B	Gas Turbine/Generator Lube Oil Aerial Cooler Package Pump	2
2B-PM3172A/B	Gas Turbine/Generator Lube Oil Aerial Cooler Package Pump Motor	2
2B-PK314	Gas Turbine/Generator Package	1
Co-Generation Building (2B-BU-393) total indoor sound power level of 119 dBA		

Table 2.4-25 Phase 2B Diluent Pump Building (2B-BU-490) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-K593	Vapour Recovery Unit 1st Stage Compressor	1
2B-KM593	Vapour Recovery Unit 1st Stage Compressor Motor	1
2B-K597	Vapour Recovery Unit 2nd Stage Compressor	1
2B-KM597	Vapour Recovery Unit 2nd Stage Compressor Motor	1
2B-P595	Vapour Recovery Unit Liquid Recycle Pump	1
2B-P403A/B/C	Diluent Pump	3
2B-PM403A/B/C	Diluent Pump/Motor	3
2B-P110A/B	Sales Oil Transfer Pump	2
2B-PM110A/B	Sales Oil Transfer Pump/Motor	2
Diluent Pump Building (2B-BU-490) total indoor sound power level of 118 dBA		

Table 2.4-26 Phase 2B Potable Water Building (2B-BU-567) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-P569	Nanofilter Feed Pump/ Motor	1
2B-P5661	Treated Water Distribution Pump/Motor (Jockey)	1
2B-P5662A/B	Treated Water Distribution Pump/Motor	2
2B-P5663	Treated Water Sodium Hypochlorite Injection Pump/Motor	1
2B-P5681	Greensand Filter Feed Pump/Motor	1
2B-P5682	Greensand Filter Backwash Pump/Motor	1
2B-P5684	Hypochlorite Injection Pump/motor	1
2B-P5685	Potassium Permanganate Injection Pump/Motor	1
2B-P5687	Greensand Filter Feed Tank Blower	1
2B-P5693	Nanofiltration system Booster Pump/Motor	1
2B-P5694	Clean In Place (CIP) Pump/Motor	1
2B-P5695	Hydrochloric Acid Injection Pump/Motor	1
2B-P5696	Antiscalent Injection Pump/Motor	1
2B-P5697	Sodium Metabisulfate Injection Pump/Motor	1
Potable Water		
Building (2B-BU-567) total indoor sound power level of 118 dBA		

Table 2.4-27 Phase 2B Lift Gas Compressor Building (2B-BU-580) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-P5824	Lift Gas Compressor Pre-lube Pump	1
2B-K582A/B	Lift Gas Compressor	2
2B-KM582A/B	Lift Gas Compressor Motor	2
Lift Gas Compressor Building (2B-BU-580) total indoor sound power level of 114 dBA		

Table 2.4-28 Phase 2B Amine Building (2B-BU-690) Indoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity
2B-P505	Filming Amine Pump (HP)/Motor	1
2B-P515	Filming Amine Pump (LP)/Motor	1
2B-K600	Sour Gas Compressor	1
2B-P600	Amine Recirculation Pumps	2
2B-P601	Amine Storage Pumps	2
2B-P602	Amine Condenser Pump	1
Amine Building (2B-BU-690) total indoor sound power level of 116 dBA		

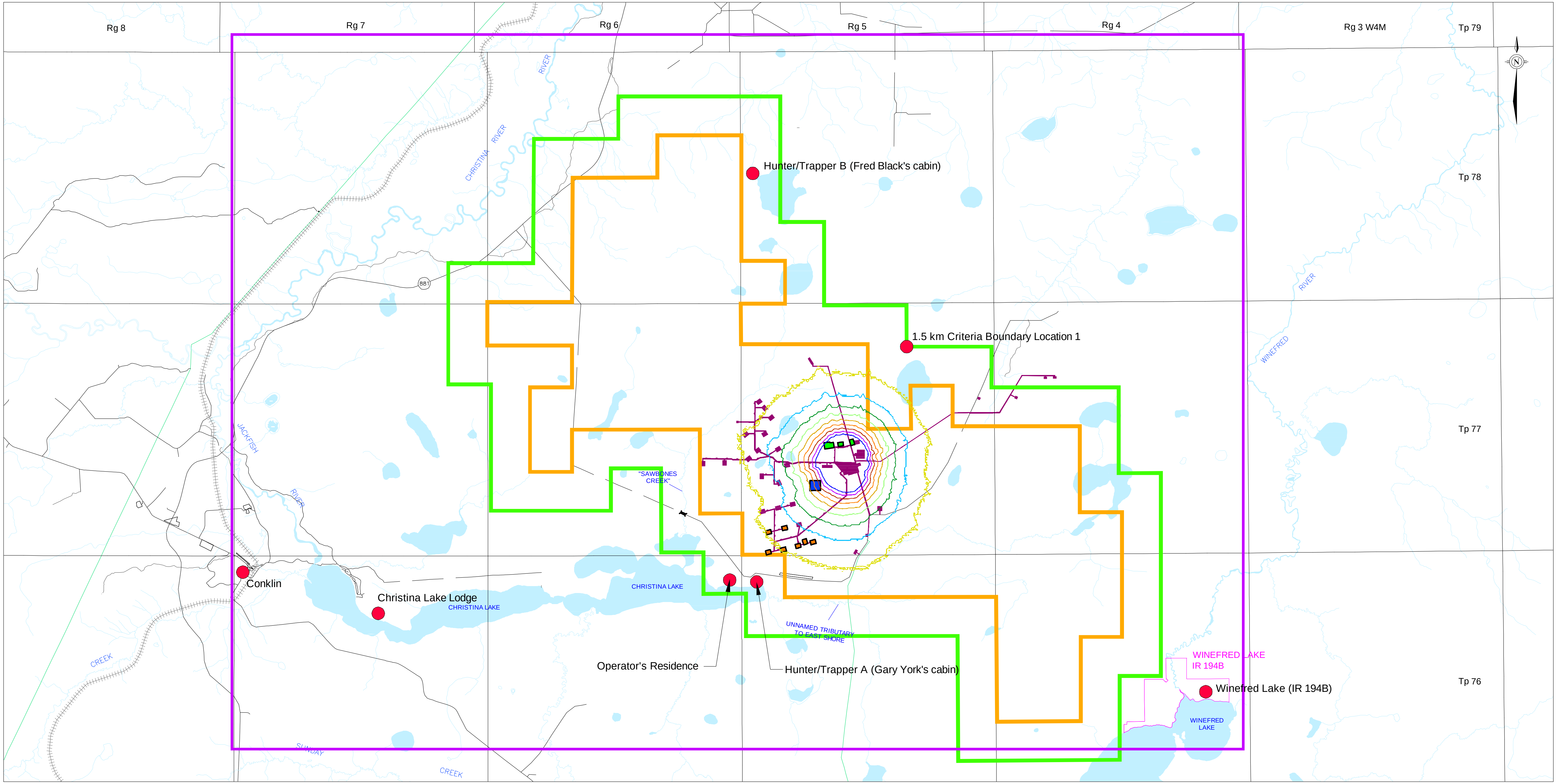
Table 2.4-29 Phase 2B Outdoor Noise Emission Sources

Equipment ID	Noise Emission Sources	Quantity	Sound Level at 1 m [dBA]	Sound Power [dBA]
2B-PK330	Steam Generator Stack	4	n/a	92
2B-PK314	Gas Turbine Exhaust Stack	1	n/a	94
2B-PK350	Heat Recovery Steam Generator	1	n/a	97
2B-PK314	Gas Turbine Air Inlet	1	n/a	97
2B-EA510	Glycol Cooler	1	85	n/a
2B-PK518	Glycol Heater	1	85	n/a
2B-PK040	Wellpad ‘G-N’ Instrument Air Compressor Building	7	n/a	68
	Air Handling Unit and Motor for 2B-BU-290	1	n/a	97
	Air Make-up Unit for 2B-BU-390	1	n/a	97
2B-I611	Train 1 Incinerator	1	85	n/a
2B-K611	Train 1 Reaction Furnace Air Blower	1	85	n/a
2B-K612	Train 1 Incinerator Air Blower	1	85	n/a
3A-I611	Train 2 Waste Heat Boiler	1	85	n/a
3A-K611	Train 2 Reaction Furnace	1	85	n/a
3A-K612	Train 2 Reaction Furnace Air Blower	1	85	n/a
3A-K641	Train 2 Incinerator	2	85	n/a
3A-P516	Train 2 Incinerator Air Blower	1	85	n/a
2B-K641	Molten Sulphur Degassers Air Blowers	2	85	n/a
2B-P516	Glycol Make-up Pump/Motor	1	85	n/a
2B-P549	Utility Well Water Pump/Motor	1	85	n/a

n/a = Not applicable.

2.4.3 Existing and Approved Case Noise Levels

Noise emissions for the various buildings and outdoor sources were entered into the CadnaA model based on CLRP design drawings and model parameters set according to Directive 038 methodology (Appendix 3-V). Table 2.4-30 presents the results of the EAC noise modelling at the selected receptor locations as well as the highest predicted noise level along the 1.5 km criteria boundary. The value presented includes the cumulative existing and approved noise level calculated from the ambient noise level and the predicted noise contribution from Phases 1, 2 and 2B. Figure 2.4-1 presents the predicted EAC noise for the LSA.



3 0 3

SCALE 1:150,000 KILOMETRES

LEGEND

- ROAD
- RAILWAY
- RIVER
- PIPELINE
- OPEN WATER
- INDIAN RESERVE
- MEG LEASE BOUNDARY
- 1.5 km FROM LEASE BOUNDARY
- NOISE LOCAL STUDY AREA
- ■ PHASE 1 MODELLED WELLPAD
- ■ PHASE 2 MODELLED WELLPAD
- ■ PHASE 2B MODELLED WELLPAD
- ● RECEPTOR LOCATION
- ▬ EXISTING AND APPROVED DEVELOPMENT
- 36 dBA
- 37 dBA
- 38 dBA
- 39 dBA
- 40 dBA
- 41 dBA
- 42 dBA
- 43 dBA
- 44 dBA

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE NOISE LEVELS

MEG ENERGY CORP.

PROJ	07-1346-0009.8100		FILE No.	Exist+App Case
DESIGN	JC	07/11/07	SCALE AS SHOWN	REV. 0
CADD	TRE	12/03/08	FIGURE: 2.4-1	
CHECK	TD	17/03/08		
REVIEW	IGG	18/03/08		

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8100\8150\Fig 2.4-1 Existing and Approved Case Noise Levels.dwg Mar 25, 2008 - 1:33pm

Table 2.4-30 Existing and Approved Case Noise Levels - Phases 1, 2 and 2B

Location	Predicted Noise Levels [dBA]	Ambient Noise Level[a] [dBA]		Existing and Approved Conditions[b] [dBA]	
		Daytime	Nighttime	Daytime	Nighttime
Conklin	7	48	38	48	38
Winefred Lake	11	45	35	45	35
Hunter/Trapper Cabin A	29	45	35	45	35
Hunter/Trapper Cabin B	16	45	35	45	36
Operator's Residence	25	45	35	45	35
Christina Lake Lodge	10	45	35	45	35
1.5 km Criteria Boundary Location 1[c]	31	45	35	45	36

[a] Mandated ambient level per Directive 038.

[b] Consists of the logarithmic addition of Predicted Noise Level and Ambient Noise Level values, this calculation may result in no change to ambient noise level (e.g., 48 dBA + 7 dBA = 48 dBA).

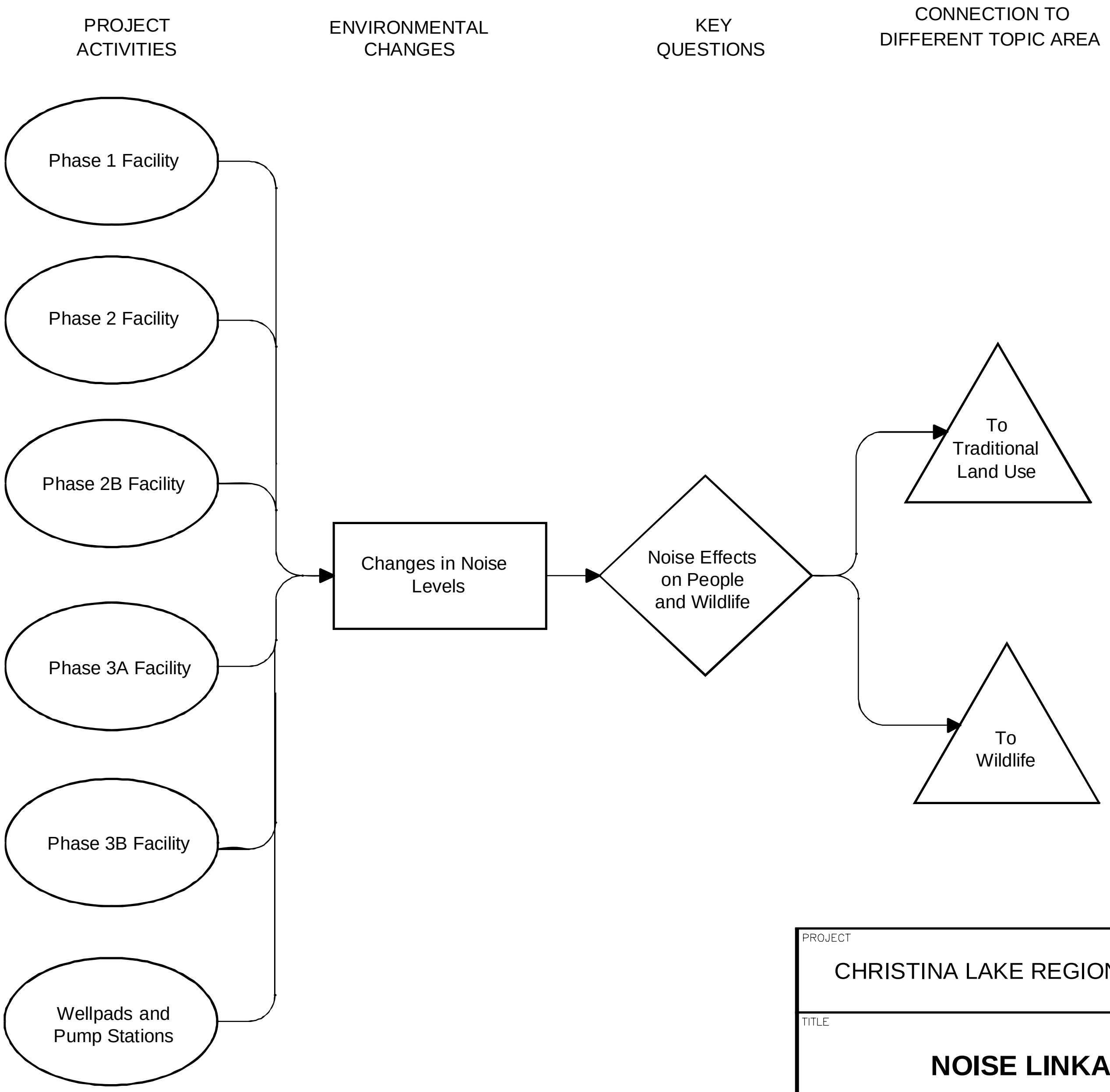
[c] Location with highest predicted existing and approved case noise level.

2.5 LINKAGE ANALYSIS

Key Question NPC-1: What effects could activities associated with existing and approved developments and the Project have on local noise levels and nearby dwellings?

The linkage diagram for NPC-1 is presented in Figure 2.5-1. As shown in the linkage diagram, equipment used in each phase of the CLRP, including the Project have the potential to affect noise levels in the environment. This resulted in a valid linkage. An impact analysis was completed for this valid linkage. In addition, results of the noise assessment are used by the Traditional Land Use assessment (Volume 6, Section 2) and Screening Level Wildlife Risk Assessment (Appendix 3-VI).

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8100\8150\Fig 2.5-1 Noise Linkage Diagram.dwg Mar 25, 2008 - 1:26pm



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

NOISE LINKAGE DIAGRAM

MEG ENERGY CORP.

PROJECT	07.1346.0009.8100	
DESIGN	CJ	07/11/07
CADD	PSR	17/12/07
CHECK	TD	17/03/08
REVIEW	IGG	18/03/08

FILE No. Noise Linkage Diag

SCALE AS SHOWN REV. 0

FIGURE: 2.5-1

2.6 PROJECT CASE

The CadnaA model was used to determine noise levels at the identified receptors and to map noise levels from the Project. Noise sources for the Project operations were appended onto the EAC model based on standard equipment operating parameters supplied by MEG. This is considered a worst-case scenario for the normal operating life of the Project as the sound emissions were considered to be constant, or operating on a continuous basis.

The Project includes two new plant facilities and changes to the sulphur recovery unit at the existing Central Plant. Plant 3A is located about 11 km southeast of the Central Plant. Plant 3B is located about 12.5 km northwest of the Central Plant. There are four new identical trains of operating equipment in total (two each at Plants 3A and 3B). Train 1 is the northern most section and Train 2 is the southern section on both of the plant facilities.

There are also 138 proposed wellpad locations within the lease boundary. The typical operating condition for the Project Case is best represented by twelve wellpads and two to three pump stations operating at the same time for both Plants 3A and 3B, for a total of 24 wellpads and five pump stations included in the noise predictions.

2.6.1 Project Case Noise Emissions

Noise emissions for the Project were established using the following:

- client-supplied project equipment lists, design data and equipment noise rating;
- field measurement of the same or similar equipment;
- referenced publications listing noise outputs for the same or similar equipment; and
- equipment specification and referenced formulae from acoustic literature such as Beranek and Ver (1992), and Bies and Hansen (2003) to estimate emissions.

Project design data were used to establish if equipment was to be enclosed in buildings or if noise controls would already be in place (e.g., silencers). The assessment focused on equipment that would be considered a major noise emitter on the site.

Once noise emissions were established, the new sources were applied to the EAC noise model to determine the incremental change in noise due to the Project. In the case of indoor noise sources, the sound transmission loss of the building envelope has been considered in the overall sound power level of the building. All pump units under the rated power of 10 kW are considered to have negligible noise emission levels and are not included in the assessment. Spectral data for each building and outdoor noise sources are found in Appendix 3-V.

2.6.1.1 Typical Train Emissions

Tables 2.6-1 to 2.6-9 list the equipment within each building associated with the operation of a single process train at either Plant Facility 3A or 3B and the corresponding noise emission levels per building. These emissions were then placed in the model for each of the four trains associated with Plants 3A and 3B.

Table 2.6-10 shows the noise emission level of outdoor noise sources associated with Plant 3A or 3B used in the assessment. The same emissions were placed at both Plant 3A and 3B sites in the model.

Table 2.6-1 Plant 3A Process Building (3A-BU-190) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-P117A/B/C	Induced Gas Flotation Froth Pump/Motor	3
3A-P116A/B/C	Induced Gas Flotation Eductor Pump/Motor	3
3A-P119A/B	Skim Oil Pump/Motor	2
3A-P120A/B	Produced Water Transfer Pump/Motor	2
3A-P121A/B	Desand Pump/Motor	2
3A-P135A/B/C	Hot Lime Softening Feed Pump/Motor	3
3A-P250A/B	Deoiling Polymer Injection Pump (PK250)	2
3A-P250A/B	Deoiling Polymer Injection Pump Motor	2
3A-P501	Reverse Demulsifier Injection Pump (PK579)	1
3A-P501	Reverse Demulsifier Injection Pump Motor	1
3A-P503	Demulsifier Injection Pump Motor	1
3A-P525A/B	Recovered Diluent Pump/Motor	2
3A-P532A/B/C	High Pressure Flare Knock Out Pump/Motor	3
3A-P541	Process Sump Pumps	6
3A-P549	Utility Well Water Pump/Motor	1
Process Building (3A-BU-190) total indoor sound power level of 120 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-2 Plant 3A Water Treatment Building (3A-BU-290) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-P202A/B/C	Raw Water Pump/Motor	3
3A-P204A/B	Dirty Backwash Transfer Pump (PK237)	2
3A-PM204A/B	Dirty Backwash Transfer Pump Motor	2
3A-P205A/B	Hot Lime Softening Recirculation Pump (PK237)	2
3A-PM205A/B	Hot Lime Softening Recirculation Pump Motor	2
3A-P206A/B/C	After Filter Backwash Pump/Motor	3
3A-P209A/B	After Filter Feed Pump/Motor	2
3A-P217A/B/C	Neutralization Pump/Motor	3
3A-P218A/B/C	Dilution/Service Pump/Motor	3
3A-P227A/B	Magox Slurry Pump (PK235)	2
3A-PM227A/B	Magox Slurry Pump Motor	2
3A-P228A/B	Lime Slurry Pump (PK236)	2
3A-PM228A/B	Lime Slurry Pump Motor	2
3A-P244A/B	Flocculent Pump (PK242)	2
3A-PM244A/B	Flocculent Pump Motor	2
3A-P261A/B	Caustic Pump (PK260)	2
3A-PM261A/B	Caustic Pump Motor	2
3A-P263A/B	Acid Dosing Pump (PK262)	2
3A-PM263A/B	Acid Dosing Pump Motor	2
3A-P267	Hot Lime Softening Sludge Sampling Pump/Motor	1
3A-P301A/B/C	Low Pressure Boiler Feed Water Pump/Motor	3
3A-P551A/B/C	Utility Water Pump/Motor	3
3A-P507A/B	O_2 Scavenger Injection Pump (PK585)	2
3A-PM507A/B	O_2 Scavenger Injection Pump Motor	2
Water Treatment Building (3A-BU-290) total indoor sound power level of 120 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-3 Plant 3A Steam Generation Building (3A-BU-390) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-PK330	Steam Generator Package	7
3A-P304A/B/C	High Pressure Boiler Feed Water Pump	3
3A-PM304A/B/C	High Pressure Boiler Feed Water Pump/Motor	3
3A-K310	Combustion Air Blower (PK330)	1
3A-KM310	Combustion Air Blower Motor (PK330)	1
3A-P311A/B/C	Boiler Feed Water Head Pump	3
3A-PM311A/B/C	Boiler Feed Water Head Pump Motor	3
3A-K353A/B	Scanner Cooling Air Blower	2
3A-KM353A/B	Scanner Cooling Air Blower Motor	2
3A-K571	Plant Instrument Air Compressor (PK517)	1
3A-KM571	Plant Instrument Air Compressor Motor (PK517)	1
3A-P505A/B	Filming Amine Pump (High Pressure) (PK586)	2
3A-PM505A/B	Filming Amine Pump (High Pressure) Motor	2
3A-P515A/B	Filming Amine Pump (Low Pressure) (PK586)	2
3A-PM515A/B	Filming Amine Pump (Low Pressure) Motor	2
Steam Generation Building (3A-BU-390) total indoor sound power level of 129 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-4 Plant 3A Diluent Pump Building (3A-BU-490) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-P110A/B/C	Sales Oil Transfer Pump	3
3A-PM110A/B/C	Sales Oil Transfer Pump Motor	3
3A-P403A/B/C	Off-Spec Pump	3
3A-PM403A/B/C	Off-Spec Pump Motor	3
3A-P406A/B/C	Diluent Pump	3
3A-PM406A/B/C	Diluent Pump Motor	3
Diluent Pump Building (3A-BU-490) total indoor sound power level of 116 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-5 Plant 3A Slop Treater Building (3A-BU-493) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-P411	Slop Treater Pump (PK408)	1
3A-PM411	Slop Treater Pump Motor	1
3A-P413	Slop Treater Hydrocarbon Pump (PK408)	1
3A-P414	Slop Treater Water Pump	1
Slop Treater Building (3A-BU-493) total indoor sound power level of 109 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-6 Plant 3A Vapour Recovery Unit Building (3A-BU-555/155) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-K593	Vapour Recovery Unit 1st Stage Compressor (PK590)	1
3A-KM593	Vapour Recovery Unit Compressor Motor (PK590)	1
3A-KM594	Vapour Recovery Unit 1st Stage Cooler Motor	1
3A-K595	Vapour Recovery Unit Eductor (PK590)	1
3A-K597	Vapour Recovery Unit 2nd Stage Compressor (PK590)	1
3A-KM597	Vapour Recovery Unit 2nd Stage Compressor Motor (PK597)	1
3A-EAM598	Vapour Recovery Unit Discharge Cooler Motor	1
Vapour Recovery Unit Building (3A-BU-555) total indoor sound power level of 114 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-7 Plant 3A Potable Water Building (3A-BU-567) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-P569	Nanofilter Feed Pump (PK565)	1
3A-PM5661	Treated Water Distribution Pump Motor (Jockey) (PK565)	1
3A-P5661	Treated Water Distribution Pump (Jockey)	1
3A-P5662A/B	Treated Water Distribution Pump (PK565)	2
3A-PM5662A/B	Treated Water Distribution Pump Motor	2
3A-P5663	Treated Water Sodium Hypochlorite Injection Pump (PK565)	1

Table 2.6-7 Plant 3A Potable Water Building (3A-BU-567) Indoor Noise Emission Sources (Typical Train) (continued)

Equipment ID	Noise Emission Sources	Quantity
3A-PM5663	Treated Water Sodium Hypochlorite Injection Pump Motor	1
3A-P5681	Greensand Filter Feed Pump (PK565)	1
3A-PM5681	Greensand Filter Feed Pump Motor	1
3A-P5682	Greensand Filter Backwash Pump (PK565)	1
3A-PM5682	Greensand Filter Backwash Pump Motor	1
3A-P5684	Hypochlorite Injection Pump (PK565)	1
3A-PM5684	Hypochlorite Injection Pump Motor	1
3A-P5685	Potassium Permanganate Injection Pump (PK565)	1
3A-PM5685	Potassium Permanganate Injection Pump Motor	1
3A-P5687	Greensand Filter Feed Tank Blower	1
3A-P5691	Nanofilter Feed Pump Motor	1
3A-P5693	Nanofiltration system Booster Pump (PK565)	1
3A-PM5693	Clean In Place (CIP) Pump (PK565)	1
3A-P5693	Nanofiltration System Booster Pump Motor	1
3A-PM5693	Clean In Place (CIP) Pump Motor	1
3A-P5694	Sodium Metabisulfate Injection Pump (PK565)	1
3A-PM5694	Sodium Metabisulfate Injection Pump Motor	1
3A-P5695	Hydrochloric Acid Injection Pump (PK565)	1
3A-PM5695	Hydrochloric Acid Injection Pump Motor	1
3A-P5696	Antiscalent Injection Pump (PK565)	1
3A-PM5696	Antiscalent Injection Pump Motor	1
Potable Water Building (3A-BU-567) total indoor sound power level of 118 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-8 Plant 3A Lift Gas Compressor Building (3A-BU-580) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-K582A/B	Lift Gas Compressor	2
3A-KM582A/B	Lift Gas Compressor Motor	2
3A-EAM583	Lift Gas Cooler Motor	1
Life Gas Compressor Building (3A-BU-580) total indoor sound power level of 114 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-9 Plant 3A Amine/Dehydration/Compressor Building (3A-BU-690) Indoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity
3A-K600	Sour Gas Compressor	1
3A-P600	Amine Recirculation Pumps	2
3A-P601	Amine Storage Pumps (PK600)	2
3A-P602	Amine Condenser Pump (PK600)	1
3A-K610	Acid Gas Transfer Compressor Package	1
3A-PK620	Acid Gas Dehydration Package	1
Amine/Dehydration /Compressor Building (3A-BU-690) total indoor sound power level of 116 dBA		

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

Table 2.6-10 Phase 3A Outdoor Noise Emission Sources (Typical Train)

Equipment ID	Noise Emission Sources	Quantity	Sound Level at 1 m [dBA]	Sound Power [dBA]
3A-PK330	Steam Generator Stack	7	n/a	92
3A-EA510	Glycol Cooler	1	85	n/a
3A-PK518	Glycol Heater	1	85	n/a
3A-PK040	Wellpad Instrument Air Compressor Building (as per Phase 3A)	12	n/a	68
	Air Handling Unit and Motor for 2B-BU-290	1	n/a	97
	Air Make-up unit for 2B-BU-390	1	n/a	97
	Wellpad Pump Station building (for all Phase 3A and 3B)	5	n/a	88
	Wellpad Pump Station cooler (for all Phase 3A and 3B)	5	n/a	108
3B-I611	Train 3 Waste Heat Boiler	1	85	n/a
3B-K611	Train 3 Reaction Furnace	1	85	n/a
3B-K612	Train 3 Reaction Furnace Air Blower	1	85	n/a
3B-K641	Train 3 Incinerator	2	85	n/a
3B-P516	Train 3 Incinerator Air Blower	1	85	n/a

n/a = Not applicable.

Note: Equipment ID represents only equipment in Plant 3A buildings. Identical equipment will be used in Plant 3B buildings.

2.6.1.2 Steam Assisted Gravity Drainage Reservoir Repressurization Compressor Buildings

Table 2.6-11 lists the equipment within each of two reservoir repressurization compressor buildings associated with the Project and the corresponding noise emission levels per building. Table 2.6-12 lists the equipment and noise emission levels outside each of the two reservoir repressurization compressor buildings. One of the buildings is located at the northeast corner of the Phase 3A facility area while the second compressor building is located at the southwest of the Phase 2/2B central facility.

Table 2.6-11 Steam Assisted Gravity Drainage Reservoir Repressurization Compressor Building Indoor Noise Emission Sources

Noise Emission Sources	Quantity
Booster Gas Compressors	2
Booster Gas Compressor Motors	2
Multistage Reciprocal Gas Compressors	2
Multistage Reciprocal Gas Compressor Motors	2
Final Gas Compressors	2
Final Gas Compressor Motors	2
Compressor Building total indoor sound power level of 133 dBA	

Table 2.6-12 Steam Assisted Gravity Drainage Reservoir Repressurization Compressor Building Outdoor Noise Emission Sources

Noise Emission Sources	Quantity	Sound Level at 1 m [dBA]	Sound Power [dBA]
Booster Gas Cooler Fans	2	n/a	98
Multistage Reciprocal Gas Cooler Fans	2	n/a	101
Final Gas Cooler Fans	2	n/a	98

n/a = Not applicable.

2.6.2 Wellpad Pump Stations

Table 2.6-13 lists the equipment within each of the five pump station buildings associated with the operation and the corresponding noise emission levels per building.

Table 2.6-13 Typical Pump Station Building Indoor Noise Emission Sources

Noise Emission Sources	Quantity
Compressor	2
Compressor Motor	2
Booster Pump	2
Booster Pump Motor	2
Pipeline Pump	2
Pipeline Pump Motor	2
Water Pump	2
Water Pump Motor	2
Pump Station Building total indoor sound power level of 114 dBA	

Table 2.6-14 shows the noise emission level of outdoor noise sources associated with each of the five pump stations used in the assessment.

Table 2.6-14 Typical Pump Station Outdoor Noise Emission Sources

Noise Emission Sources	Quantity	Sound Power [dBA]
Wellpad Pump Station Building	2	88
Wellpad Pump Station Cooler	2	108

2.6.3 Project Case Noise Level Predictions

Table 2.6-15 presents the results of the Project Case noise modelling at the selected receptor locations as well as the highest predicted noise level along the 1.5 km criteria boundary. The value presented includes the cumulative Project Case noise level calculated from the mandated ERCB ambient noise level and the predicted Project noise contribution from Phase 1, 2, 2B and 3 operation. Figure 2.6-1 presents the predicted Project Case noise for the LSA.

Table 2.6-15 Project Case Noise Levels - Phase 1, 2, 2B and 3

Location	Predicted Noise Levels [dBA]	Ambient Noise Level [dBA](a)		Project Case [dBA](b)	
		Daytime	Nighttime		
Conklin	12	48	38	48	38
Winefred Lake (IR 194B)	21	45	35	45	35
Hunter/Trapper Cabin A (Gary York's cabin)	26	45	35	45	35
Hunter/Trapper Cabin B (Fred Black's cabin)	20	45	35	45	36
Operator's Residence	25	45	35	45	35
Christina Lake Lodge	15	45	35	45	36
1.5 km Criteria Boundary Location 2(c)	38	45	35	45	40

(a) Mandated ambient level per directive 038.

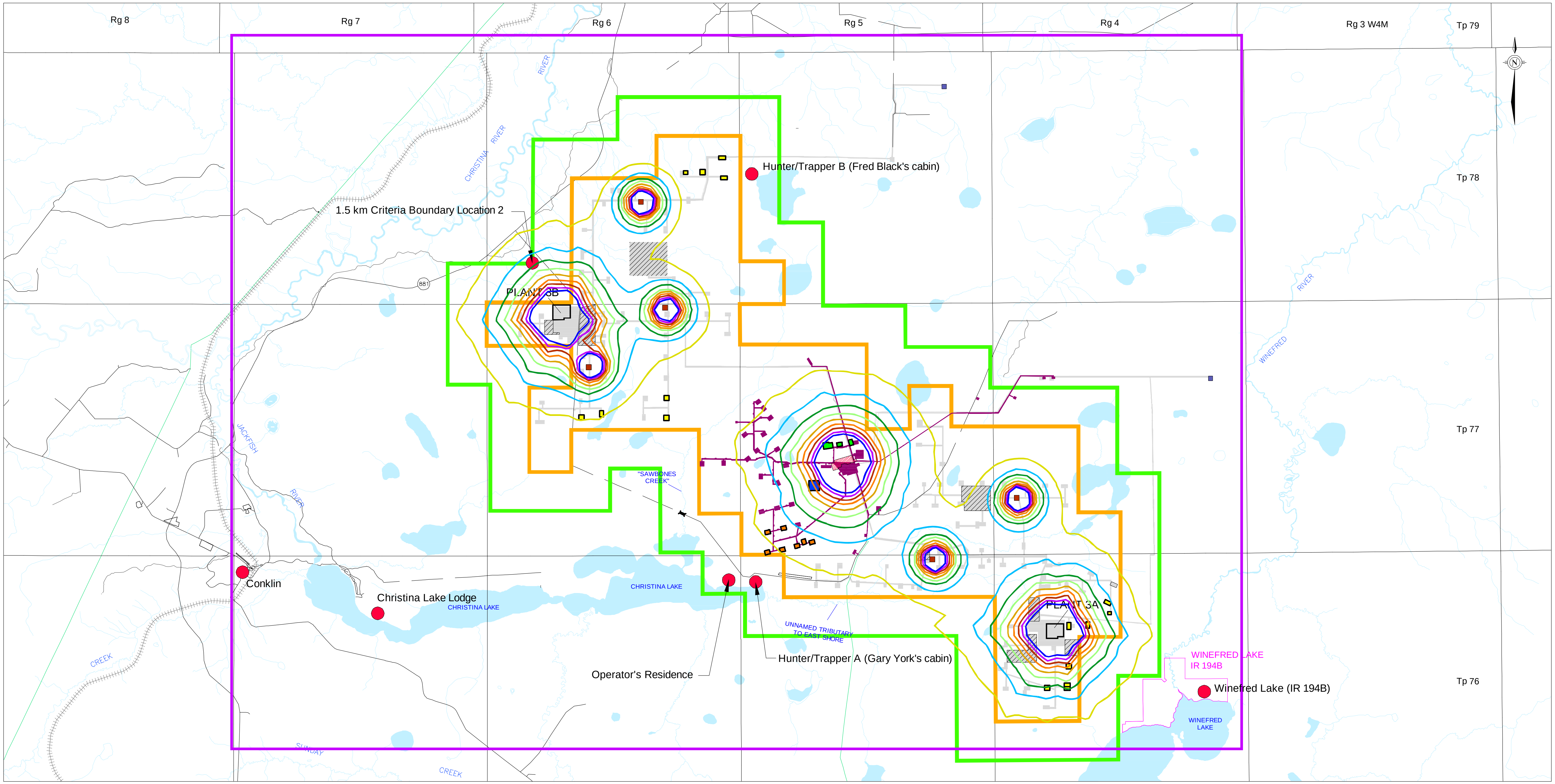
(b) Consists of the logarithmic addition of predicted and ambient values.

(c) Location with highest predicted Project Case noise level, this differs from the location of highest predicted noise levels in the EAC.

2.6.4 Low Frequency Noise

Directive 038 indicates that, if data are available, a calculation should be completed to determine the potential for LFN noise from a development. Early determination of potential allows for LFN noise consideration during the construction of a facility, when the most effective mitigation can be employed.

Data regarding the spectral signature of Project sources have been established either through measurement or empirical formula. This mix of spectral data, while representative of potential overall noise from the site, is not detailed enough to provide a reliable estimate of LFN effects from the Project. Therefore, while the potential for LFN is assessed, LFN levels need to be verified during the detailed design stage, when vendor-specific data for all sources are available.



LEGEND

▬	ROAD
┼┼┼┼┼	RAILWAY
─	RIVER
─	PIPELINE
▭	OPEN WATER
▭	INDIAN RESERVE
▭	MEG LEASE BOUNDARY
▭	1.5 km FROM LEASE BOUNDARY
▨	CENTRAL PLANT
▭	NOISE LOCAL STUDY AREA
■	PHASE 3 PUMP STATION
■	PHASE 1 MODELLED WELLPAD
■	PHASE 2 MODELLED WELLPAD
■	PHASE 2B MODELLED WELLPAD
■	PHASE 3 MODELLED WELLPAD
●	RECEPTOR LOCATION
■	EXISTING AND APPROVED DEVELOPMENT
■	PROJECT FOOTPRINTS
▨	BORROW AREAS
▭	36 dBA
▭	37 dBA
▭	38 dBA
▭	39 dBA
▭	40 dBA
▭	41 dBA
▭	42 dBA
▭	43 dBA
▭	44 dBA

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

3 0 3

SCALE 1:150,000 KILOMETRES

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE NOISE LEVELS

MEG ENERGY CORP.

PROJ	07–1346–0009.8100	
DESIGN	JC	07/11/07
CADD	TRE	12/03/08
CHECK	TD	17/03/08
REVIEW	IGG	18/03/08

FILE No. Noise levels

SCALE AS SHOWN

REV. 0

FIGURE: 2.6-1

L:\2007\1346 Oil Sands\07–1346–0009–MEG EXPANSION\8100\8150\Fig 2.6–1 Project case noise levels.dwg Mar 25, 2008 – 1:35pm

To assess the potential for LFN effects at the identified noise receptors, the overall noise contributions from the Project were recalculated with the C-weighted filter (Appendix 3-V) and compared to the A-weighted results as presented in Table 2.6-15. The results are summarized in Table 2.6-16. The difference between the two weightings for all receivers is higher than the 20 dB Directive 038 guideline. Therefore, there is potential for LFN at all receptors even though the Project contributions in dBA are lower than the ERCB ambient guideline of 35 dBA. Detailed spectral data are provided in Appendix 3-V.

It is important to note that the A-weighted or C-weighted ambient levels have not been included in the analysis. There is no information available for the C-weighted average rural ambient nighttime and daytime sound levels. It is expected that the difference (dBA-dBC) would be considerably less if the ambient level is incorporated in the analysis.

Table 2.6-16 Low Frequency Noise Analysis

Location	Project Sources [dBA]	Project Sources [dBC]	Difference [dBC – dBA]
Conklin	12	40	28
Winefred Lake (IR 194B)	21	43	22
Hunter/Trapper Cabin A (Gary York's cabin)	26	52	26
Hunter/Trapper Cabin B (Fred Black's cabin)	20	45	25
Operator's Residence	25	51	26
Christina Lake Lodge	15	43	28
1.5 km Criteria Boundary	38	58	20

The calculations show the primary sources of LFN are the steam generator stacks and glycol cooler inlets. 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.

Tonal components from the Project have not been assessed since vendor-supplied or tested spectra for most equipment are not available at this stage of design.

2.6.5 Project Case Impact Assessment

2.6.5.1 Construction

The Project will require the construction of Plants 3A and 3B, wellpads, wellpad pump stations and an expansion of the Sulphur Recovery Unit at the Central Plant. The equipment that will be used for construction activities may generate sound that could be detected by the sensitive receptors in this assessment.

However, any noise due to construction is temporary, as the activities vary and will move between the facilities and to the various wellpad locations. Any noise concerns raised by stakeholders during the construction activities will be addressed directly by MEG.

2.6.5.2 Operations

The activities associated with operations will result in the generation of additional sound from the Phase 3 facilities despite the design features incorporated in the Project. The impact magnitude associated with changes in noise levels has been determined based on the process described in Section 2.2.9.

The assessment of noise effects associated with the Project considered the sound emissions associated with the fully developed Phase 3 facilities, the wellpads and the associated pump stations closest to the selected receptor. Table 2.6-17 provides a comparison of noise level contributions from the EAC and Project Case noise levels with the ERCB criteria to determine compliance at the noise receptors. The results of the evaluation indicate that the cumulative noise levels due to the Project as well as the existing and approved facilities will be below the day and night PSL values at the selected receptors. In addition, noise levels at the 1.5 km criteria boundary are all below the ERCB criteria of 40 dBA.

Table 2.6-17 Comparison of Noise Predictions and Energy Resources Conservation Board Criteria for the MEG Christina Lake Regional Project – Phase 3

Location	Existing and Approved Case Noise Level [dBA] [a]		Project Case Noise Level[b] [dBA]		PSL [dBA]	
	Day	Night	Day	Night	Day	Night
Conklin	48	38	48	38	53	43
Winefred Lake (IR 194B)	45	35	45	35	50	40
Hunter/Trapper Cabin A (Gary York's cabin)	45	35	45	35	50	40
Hunter/Trapper Cabin B (Fred Black's cabin)	45	36	45	36	50	40
Operator's Residence	45	35	45	35	50	40
Christina Lake Lodge	45	35	45	36	50	40
1.5 km Criteria Boundary Location 2	45	35[c]	45	≥38	50	40

[a] Logarithmic sum of ambient noise level and noise contribution from Phase 1, 2 and 2B.

[b] Logarithmic sum of ambient noise level and noise contribution from Phase 1, 2, 2B and 3.

[c] This noise level corresponds to the location with highest noise level in the Project Case, which is different from the location with highest noise level in the EAC.

Table 2.6-18 shows the predicted amount of change in the noise levels at the receptors due to the Project.

Table 2.6-18 Expected Change in Combined Noise Levels Due to the Project

Location	Existing and Approved Case Noise Level [dBA]		Project Case Noise Level [dBA]		Change[a]	
	Day [dBA]	Night [dBA]	Day [dBA]	Night [dBA]	Day [dBA]	Night [dBA]
Conklin	48	38	48	38	0	0
Winefred Lake (IR 194B)	45	35	45	35	0	0
Hunter/Trapper Cabin A (Gary York's cabin)	45	35	45	35	0	0
Hunter/Trapper Cabin B (Fred Black's cabin)	45	36	45	36	0	0
Operator's Residence	45	35	45	35	0	0
Christina Lake Lodge	45	35	45	36	0	1
1.5 km Criteria Boundary[b]	45	35[b]	45	40	0	5

[a] Arithmetic difference between Existing and Approved Case and Project Case.

[b] This noise level corresponds to the location with highest noise level in the Project Case, which is different from the location with highest noise level in the EAC.

2.6.5.3 Environmental Consequence

The impact magnitude for noise was determined based the predicted change in ambient conditions and compliance with the defined PSLs as detailed in Section 2.2.9, Table 2.2-6. This approach is also illustrated in Figure 2.6-2. The magnitude ratings for all selected receptors are rated negligible to low, as summarized in Table 2.6-19.

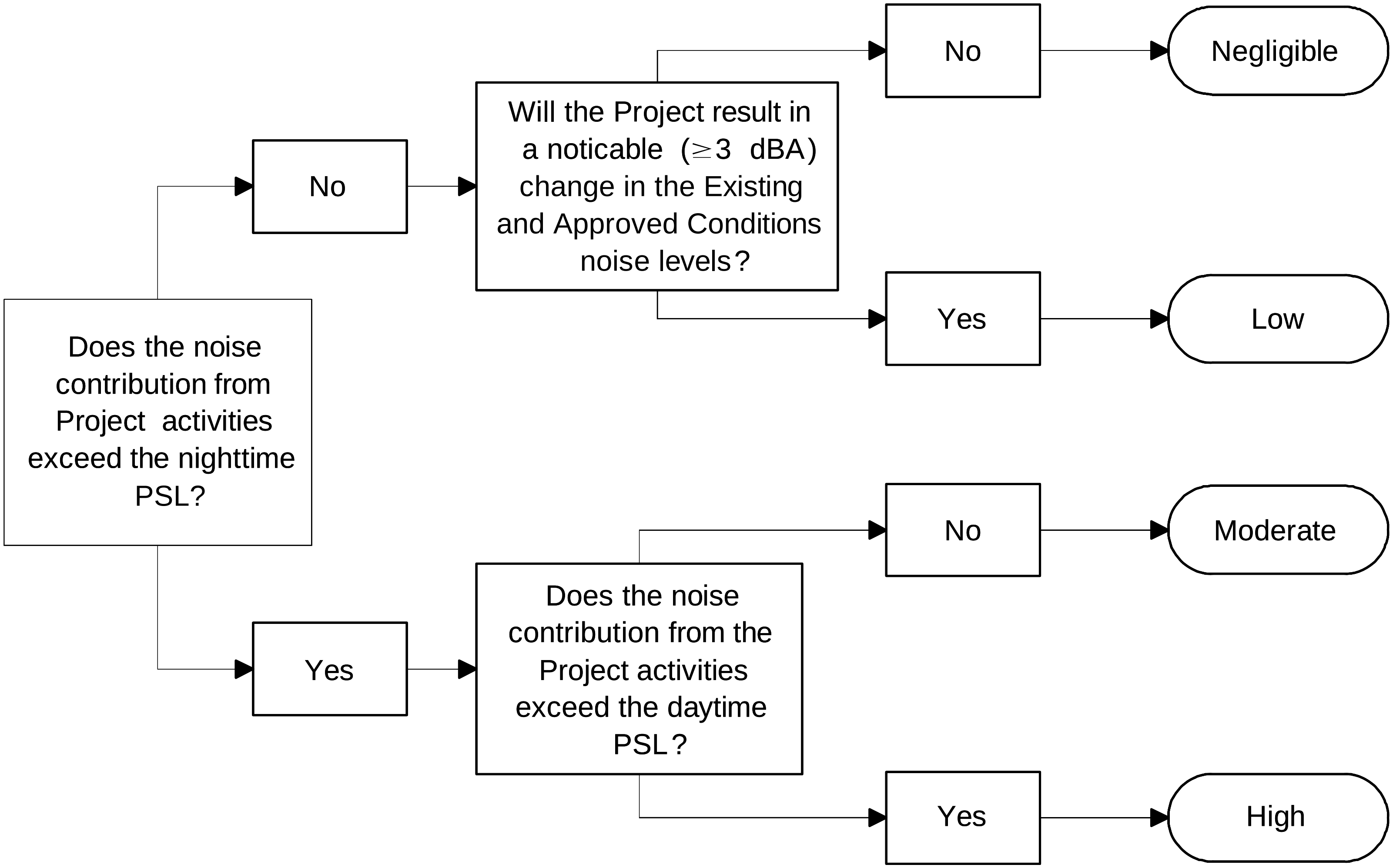
Table 2.6-19 Magnitude Classification for Noise

Receptor	Change[a]	Maximum Predicted Noise Level (Nighttime)	Magnitude Rating
Conklin	0	38	negligible
Winefred Lake (IR 194B)	0	35	negligible
Hunter/Trapper Cabin A (Gary York's cabin)	0	35	negligible
Hunter/Trapper Cabin B (Fred Black's cabin)	0	36	negligible
Operator's Residence	0	35	negligible
Christina Lake Lodge	+1	36	negligible
1.5 km Criteria Boundary	+5	40	low

[a] Arithmetic difference between the EAC and Project Case.

Using the impact magnitudes indicated in Table 2.6-20, an overall rating of the environmental consequence was determined for the noise parameter evaluated. As shown in Table 2.6-20 noise levels at the seven receptors were evaluated as having a primarily negligible environmental consequence with one receptor rated as having a low consequence.

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8100\8150\Fig 2.6-2 Magnitude Classification Decision Tree.dwg Mar 25, 2008 - 1:39pm



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

MAGNITUDE CLASSIFICATION DECISION TREE

MEG ENERGY CORP.

PROJECT	07.1346.0009.8100	
DESIGN	CJ	07/11/07
CADD	TRE	28/01/08
CHECK	TD	17/03/08
REVIEW	IGG	18/03/08

FILE No. Decision Tree

SCALE AS SHOWN REV. 0

FIGURE: 2.6-2

Table 2.6-20 Residual Impact Classification for Noise

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Conklin	neutral	negligible	regional	medium-term	reversible	high	negligible
Winefred Lake	neutral	negligible	regional	medium-term	reversible	high	negligible
Hunter/Trapper Cabin A	neutral	negligible	regional	medium-term	reversible	high	negligible
Hunter/Trapper Cabin B	neutral	negligible	regional	medium-term	reversible	high	negligible
Operator's Residence	neutral	negligible	regional	medium-term	reversible	high	negligible
Christina Lake Lodge	negative	negligible	regional	Medium-term	reversible	high	negligible
1.5 km Criteria Boundary	negative	low	regional	medium-term	reversible	high	low

Note: Classifications are conducted per the impact classification methods outlined in Volume 2 of the EIA.

The direction was determined to be neutral for all receptors, except for two locations, where there are negative changes in noise levels. Geographic extent was rated regional since all receptors were outside the 1.5 km criteria boundary. The duration of the noise is only during operations, therefore it is medium term. Noise is reversible – when the equipment shuts down, noise is no longer generated. Operations and associated noise generation is expected to be continuous; therefore, frequency of occurrence is high. In combination with the magnitude impact rating for each receptor, these elements resulted in negligible to low consequence ratings.

2.6.5.4 Scientific Uncertainty

As indicated in Section 2.2.10 and Appendix 3-V, outdoor noise attenuation is modelled using standard algorithms and assumptions that tend to simplify the acoustic environment. Normal variation of noise sources is addressed in the modelling depending on the noise source being assessed and the level of detail required.

The quality and relevance of predictions from the noise model is dependant on the data inputs. Sound emissions and site data used for the assessment were established with a high level of professional care to ensure the simulations were representative of the site.

The CadnaA model used for the assessment predicted noise levels in accordance with International Standards Organization 9613 (1&2): *Attenuation of Sound During Propagation Outdoors* (ISO 1996). The ISO 9613 method will predict noise attenuation to within ±3 dBA (ISO 1996).

2.7 MONITORING

The results of the noise assessment indicate the Project effects will be negligible at the six specific (dwelling type) receptor locations and that the environmental consequences for the project are negligible to low. Therefore, a monitoring program for noise is not recommended.

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.

2.8 PLANNED DEVELOPMENT CASE

As identified in Section 2.2.10, based on the nature of sound and past experience with similar projects, noise from industrial developments will typically attenuate to below background noise levels within 5 km of an activity (EnCana 2007). There are no planned energy-related developments within 5 km of the 1.5 km ERCB criteria boundary so there are no additional measurements or predictions that could be included in a future noise effects analysis. Therefore, the PDC does not differ from the Project Case and a separate PDC assessment was not completed for the Project.

2.9 CONCLUSIONS

Key Question NPC-1 asked what effect existing and approved developments and the Project could have on local noise levels and at dwellings. The effects of Project noise levels were determined by:

- establishing the noise levels at specific receptors for noise caused by existing and approved projects;
- predicting the amount of sound generated by the major sources of the Project; and
- evaluating the resulting noise levels at specific receptors.

Negligible to low magnitude impacts were predicted for the Project. The overall noise levels at all the seven receptors identified for the assessment met the PSL as required by Directive 038. The amount of change expected at these locations is considered to be negligible for six of the receptors since people start to notice a change in noise levels of 3 dBA and the predictions were below this level. Since ERCB criteria are met and the amount of change is relatively small, the effects of Project noise at these six receptors are considered to be of negligible consequence.

At the 1.5 km criteria boundary near Plant 3A, the predicted Project Case noise level was assigned a low impact magnitude. The predictions met the ERCB criteria with a level change from the EAC to Project Case of 3 dBA. The effects of Project noise are considered of low consequence as the change is considered audible but there is no dwelling at this location.

2.10 REFERENCES

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EnCana Corporation. 2007. Application to the ERCB for an Amendment to Approval No. 8951 and Application to AENV for an Amendment to Approval No. 48522. Volume 1, Appendix V – Noise Assessment.

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3 HUMAN HEALTH ASSESSMENT

3.1 INTRODUCTION

MEG Energy Corp. (MEG) is a Calgary-based, privately held energy company focused on the development and recovery of bitumen, shallow gas reserves and the generation of power in northeast Alberta. MEG's Christina Lake Regional Project (CLRP) consists of 80 sections of oil sands leases within the Regional Municipality of Wood Buffalo (RMWB), approximately 15 km southeast of Secondary Highway 881 and 20 km northeast of Conklin.

MEG currently has approval to construct and operate the first two phases of the CLRP over 23 sections of land. In addition, MEG is developing a facility expansion (Phase 2B) to increase the production capacity of the Central Plant to 60,000 barrels per day (bpd). The Phase 2B plant will be located immediately adjacent to the existing Phase 1 and 2 processing facilities.

MEG is now proposing a further expansion of the CLRP to fully develop its Christina Lake oil sands leases. The Christina Lake Regional Project – Phase 3 (the Project) is an expansion of the current CLRP development area and will use Steam Assisted Gravity Drainage (SAGD) bitumen recovery technology. The Project will consist of two additional processing facilities (Plants 3A and 3B), 138 SAGD multi-well pads and associated steam generating equipment. Plant 3A will be located in the southeast corner of the lease (Sections 20 and 29-76-4 W4M) and Plant 3B will be located in the northwest end of the lease (Sections 32 and 33-77-6 W4M).

Construction of the Project is proposed to occur in two phases. Phase 3A is anticipated to begin construction in 2010, with initial steam injection in 2012. Phase 3B is anticipated to begin construction in 2012, with initial steam injection in 2014. The operational life of each plant is expected to be 25 years. Total production from the two new plants will produce an incremental 150,000 bpd of bitumen (approximately 23,800 cubic metres per day). It is anticipated that reclamation of the Project will be complete by 2044.

The primary objective of the Human Health Risk Assessment (HHRA) section of the Environmental Impact Assessment (EIA) was to describe the nature and significance of potential health risks that might be associated with emissions from the proposed MEG Christina Lake Regional Project (CLRP) – Phase 3 (the Project). The HHRA examined both short-term (acute) and long-term (chronic) health risks attributable to the Project combined with existing and approved developments, as well as with other proposed or planned developments for the region.

To quantify potential health risks, predicted ground-level air concentrations and intake levels from multiple routes of exposure were compared to exposure limits that are intended to be protective of human health.

3.2 SCOPE OF ASSESSMENT

The key features influencing the scope of the HHRA are outlined below and discussed in detail in the sections following:

- identification of the Terms of Reference (TOR) issued by Alberta Environment (AENV 2008) that will be addressed as part of the HHRA; and
- determination of the health-related concerns expressed by key stakeholders regarding potential health risks associated with the Project.

3.2.1 Terms of Reference

This assessment was completed to meet the relevant TOR (AENV 2008) for the Project (Table 3.2-1) which state the following:

Table 3.2-1 Terms of References Addressed by the Human Health Risk Assessment

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
7.0 PUBLIC HEALTH AND SAFETY ASSESSMENT		
7.0 PUBLIC HEALTH AND SAFETY ASSESSMENT	[A] Describe those aspects of the Project that may have implications for public health or the delivery of regional health services. Determine whether there may be implications for public health arising from the Project. Specifically: (a) assess the potential health implications of the compounds that will be released to the environment from the proposed operation in relation to exposure limits established to prevent acute and chronic adverse effects on human health;	(a) Volume 3, Section 3.6, Existing and Approved Case, Project Case and Planned Development Case Assessment
	(b) provide the data, exposure modeling calculations, and described the methods MEG used to assess impacts of the Project on human health and safety;	(b) Volume 3, Section 3.4, Assessment Methods; Volume 3, Appendix 3-VIII Multiple Pathway Exposure Model and Predicted Exposure Point Concentrations

Table 3.2-1 Terms of References Addressed by the Human Health Risk Assessment (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
7.0 PUBLIC HEALTH AND SAFETY ASSESSMENT (continued)	(c) provide information, including chemical analysis and modeling results, on samples of selected environmental media (e.g. soil, water, air, vegetation, wild game, etc.) used in the assessment;	(c) Volume 3, Section 3.4.4.2 Exposure Assessment; Volume 3, Appendix 3-VIII Multiple Pathway Exposure Model and Predicted Exposure Point Concentrations
	(d) discuss the potential for changes to water quality, air quality and soil quality to increase human exposure to contaminants taking into consideration all Project activities;	(d) Volume 3, Section 3.4 Assessment Methods and Section 3.5 Mitigation
	(e) identify the human health impact of the potential contamination to country foods and natural food sources taking into consideration all Project activities	(e) Volume 3, Section 3.6 Existing and Approved Case, Project Case and Planned Development Case Assessment
	(f) document the health concerns raised by stakeholders during consultation on the Project;	(f) Volume 3, Section 3.2 Scope of Assessment
	(g) document any health concerns identified by aboriginal communities or groups due to impacts of existing development and of the Project specifically on their traditional lifestyle and include an aboriginal receptor type in the assessment;	(g) Volume 3, Section 3.2 Scope of Assessment
	(h) assess the cumulative human health effects to receptors, including the First Nations and Metis receptors;	(h) Volume 3, Section 3.6 Existing and Approved Case, Project Case and Planned Development Case Assessment
	(i) as appropriate, describe anticipated follow-up work, including regional cooperative studies. Discuss how such work will be implemented and coordinated with ongoing air, soil and water quality initiatives;	(i) Volume 3, Section 3.7 Monitoring
	(j) describe the potential health impacts due to higher regional traffic volumes and the increased risk of accidental leaks and spills; and	(j) Volume 3, Section 3.6 Existing and Approved Case, Project Case and Planned Development Case Assessment
	(k) discuss mitigation strategies to minimize the potential impact of the Project on human health.	(k) Volume 3, Section 3.5 Mitigation

3.2.2 Consultation and Assessment Focus

In recognition of the need to address the concerns of the various stakeholders, MEG developed a public consultation program, which included:

- community, group and individual meetings;
- telecommunication with individuals;
- site visits;

- mail correspondence;
- public notification in regional and local news media; and
- advertisements at regional and local centres.

A complete listing of the consultation activities is provided in Volume 1, Section 5.

Concerns raised by stakeholders related to the Project's potential effects on human health included:

- risk of adverse impacts on local air quality and water quality associated with the Project in combination with existing, approved and planned developments in the region; and
- risk of adverse impacts on traditional land use activities (i.e., medicinal plant gathering, berry picking, trapping, hunting and fishing).

3.2.3 Key Questions

As described, the TOR established by AENV (2008) and the concerns identified through the consultative process helped to shape the key questions and issues that formed the focus of the environmental health assessments. The key questions for human health are listed below.

Key Question HHPDC-1: What are the risks of adverse human health effects from short-term (acute) exposure to air emissions from existing and approved developments, the Project and planned developments?

Key Question HHPDC-2: What are the risks of adverse human health effects from long-term (chronic) exposure to air emissions and water releases from existing and approved developments, the Project and planned developments?

3.3 BASELINE SUMMARY

The purpose of the following discussion on the existing conditions in the Regional Municipality of Wood Buffalo (RMWB) is to gain an understanding of how existing conditions may impact human health, as well as contribute to future exposures.

3.3.1 Current Health Status in the Region

The Project will be situated in the Northern Lights Health Region (NLHR), with a population of 74,728 based on 2005 data (ACB 2006, Website). In a recent Alberta Health and Wellness (AHW) study on the health of Albertans, the health status of people living in the NLHR were reported relative to other regions in Alberta (AHW 2006, Website). Data for the following health descriptors were provided:

- health determinants;
- mental health;
- non-communicable diseases; and
- injury.

3.3.1.1 Health Determinants

The health determinants examined by AHW (2006, Website) are listed and summarized below:

- Self-Perceived Health Status: Residents of the northern-most health regions (Aspen, Peace County and Northern Lights) were the least likely to report their health as very good or excellent compared to the rest of Alberta. In 2003, approximately 64% of Albertans reported their health to be very good or excellent, whereas, only about 58% of individuals in the NLHR reported their health as very good or excellent.
- Tobacco Use: The NLHR reported the highest smoking rates with 30% of the population smoking either occasionally or daily, compared to the provincial average of 23%.
- Cancer Screening: No statistical difference was identified between the per cent of women aged 50 to 69 reporting they received a mammogram within the previous two years and pap smears within the past three years in the NLHR and across the province.
- Body Weight: Regional differences were observed in Body Mass Index (BMI) for the overweight and obese categories. The highest proportion of the population determined to be obese was identified in the NLHR and Aspen health region compared to other health regions. Approximately 23% of the population in the NLHR had a BMI in the obese category, while only 15% of Albertans had a BMI in the obese category. The percentage of population with a BMI in the overweight category was comparable between the NLHR and the provincial average (approximately 34%).

- Nutrition: The NLHR had the lowest proportion of individuals reporting that they consume five or more servings of fruits and vegetables relative to other health regions. Approximately 36% of Albertans reported consuming the Health Canada recommended serving of fruits and vegetables, whereas, approximately 28% of individuals in the NLHR reported consuming five or more servings of fruits and vegetables.
- Alcohol Use: Rates of heavy drinking (five or more drinks on one occasion 12 or more times per year) were highest in the NLHR in 2003. In the NLHR, approximately 28% of individuals fell into the heavy drinker category. In general, 22% of Albertans were defined, on this basis, as heavy drinkers.
- Physical Activity: The percent of individuals in the NLHR reporting being active or moderately active during leisure time (approximately 52%) was similar to the provincial average of approximately 54%.

3.3.1.2 Mental Health

The NLHR had significantly lower prevalence estimates for mental health problems and anxiety disorders/depression than the provincial average of 15.4 and 11.9%, respectively. However, substance abuse disorder treatment was significantly higher in the NLHR relative to the provincial average of 0.7% (AHW 2006, Website).

3.3.1.3 Non-Communicable Disease

The AHW (2006, Website) study focused on the most common non-communicable diseases:

- Cancer: In 2001 to 2003, the Age Standardized Incidence Rates (ASIR) for all invasive cancers (per 100,000 population, all ages) was lower in the NLHR than the provincial average for females (ACB 2006, Website). There was no significant difference in ASIRs for males (ACB 2006). Age-Standardized Mortality Rates (ASMR) in the NLHR were similar (no significant difference) to the provincial average for both sexes (ACB 2006, Website). In general, the likelihood of developing any of the four most common cancers in Alberta (prostate, breast, colorectal and lung) increases with age (ACB 2006, Website). Rates of these common cancers are discussed for the NLHR and province below (ACB 2006, Website).
    - Prostate: No significant differences in ASIRs and ASMRs were identified between the NLHR and the provincial average.
    - Breast: ASIR (approximately 65 per 100,000) were significantly lower for females in the NLHR compared to the province (110 per

  100,000), but there was no significant difference in ASMRs for breast cancer across the province.
  - Colorectal: No significant differences in ASIRs and ASMRs were identified between the NLHR and the provincial average.
  - Lung: No significant differences in ASIRs and ASMRs were identified between the NLHR and the provincial average.

- Cardiovascular Disease: Age-standardized treated prevalence (per 100 population) of ischaemic heart disease was significantly higher in the NLHR than the provincial average;
- Cerebrovascular Disease: In the NLHR, age-standardized treated prevalence (per 100 population) of cerebrovascular disease was significantly lower than the provincial average;
- Hypertension: Age-standardized treated prevalence (per 100 population) of hypertension was significantly higher in the NLHR than the provincial average; and
- Chronic Respiratory Disorders: Age-standardized treated prevalence (per 100 population) for asthma was significantly lower in the NLHR than the provincial average, but significantly higher for chronic bronchitis and Chronic Obstructive Pulmonary Disease (COPD).

In an additional study, Wang et al. (1996, Website) found that hospital admission rates for asthma and bronchitis from 1990 to 1994 were higher in northern Alberta, specifically in Fort McMurray, than the provincial average, but emphysema hospital admission rates in Fort McMurray were found to be lower. As well, in Fort McMurray, a higher rate of physician visits for asthma but a lower rate for bronchitis and emphysema was found.

It has been suggested that a diagnostic shift may be responsible for simultaneous increases in asthma cases and decreases in bronchitis cases (Wang et al. 1996, Website). There are also factors that influence whether people are more likely to visit a physician versus going to the hospital. Wang et al. (1996, Website) point out that the rate of mortality, hospital admissions and physician visits may depend upon several factors, including:

- underlying incidence and prevalence of disease studied;
- diagnostic patterns among physicians;
- public and individual awareness of disease;
- severity of disease;

- accessibility to physician/hospital services;
- patterns of seeking medical services among population groups;
- practice patterns of physicians, emergency rooms and/or hospitals; and
- disease reporting and coding practices.

A true elevation in a particular disease outcome in an area would likely be reflected in both hospitalization rates and physician visits (AHW 1999, Website).

- Diabetes: Age-standardized treated prevalence (per 100 population) of diabetes was significantly higher in the NLHR than the provincial average;
- Chronic Renal Failure: Although not significant, age-standardized treated prevalence (per 100 population) of chronic renal failure was lower than the provincial average; and
- Arthritis: Age-standardized treated prevalence (per 100 population) of arthritis was significantly higher in the NLHR than the provincial average.

3.3.1.4 Injury

Although not statistically significant, age-standardized treated prevalence (per 100 population) of injury was higher in the NLHR than the population of Alberta. In the NLHR, the age-standardized mortality rate (per 100 population) was lower for suicide and higher for homicide than the provincial average (AHW 2006, Website).

3.3.2 Regional Air Quality and Human Health Studies

The Alberta Oil Sands Community Exposure and Health Effects Assessment Program is a joint industry, government and community initiative established to investigate possible links between air quality and human health outcomes in the Fort McMurray region (AHW 2000). In addition, the Wood Buffalo Environmental Association (WBEA), of which MEG has applied for membership, is involved in an ongoing Human Exposure Monitoring Program (HEMP) to continuously monitor certain air contaminants that individuals are exposed to on a chronic basis during daily activities and in various environments in the Oil Sands Region. It was developed to ensure a long-term systematic approach to data gathering that would improve knowledge about the potential link between air quality and human health in the region. The HEMP began in

2005 in Fort McMurray and Fort Chipewyan with the first report being released in February 2007 (WBEA 2007).

Similar to the study objectives for the Alberta Oil Sands Community Exposure and Health Effects Assessment Program, HEMP intends to:

- examine the relationship between the concentrations of selected air contaminants in personal, indoor and outdoor air;
- examine the factors affecting human exposure to air contaminants;
- determine trends in air contaminant levels that people of Wood Buffalo are exposed to; and
- establish possible links between air quality and any potential health-related effects.

Results from the AHW study showed chemical concentrations in air to be generally low in the Fort McMurray region, compared to air quality guidelines, regardless of whether they were measured indoors or outdoors (AHW 2000). Air concentrations were not significantly different in Fort McMurray when compared to a reference location (Lethbridge, Alberta), despite the high degree of oil and gas development in the Fort McMurray region. Secondly, no significant differences in health status were found between the two community populations regarding physician visits or disease prevalence.

The AHW (2000) report and the more recent information from the WBEA HEMP Report (WBEA 2007) suggest the following:

- Nitrogen dioxide (NO_2) concentrations were low compared to air quality guidelines, although levels have increased since the AHW (2000) study. Indoor concentrations were lower than outdoor concentrations. The most important exposure sources were local, suggesting that regional development has little influence.
- Sulphur dioxide (SO_2) concentrations were low compared to air quality guidelines, and in general, outdoor air concentrations in the HEMP Report (WBEA 2007) were similar to the AHW (2000) levels. Indoor concentrations were lower than outdoor levels. The most important significant exposure sources were determined to be local, followed by regional sources. Because regional emissions contribute to exposure, industrial emissions in the area must be incorporated into the air quality assessment.
- Ozone (O_3) indoor and personal concentrations were lower than the 1-hour Alberta Ambient Air Quality Object (AAAQO) of 160 $\mu g/m^3$

and 8-hour Canada-Wide Standard (CWS) of 125 µg/m^3; outdoor ambient levels were an order of magnitude higher, with the most important exposure source being naturally occurring background sources.

- Indoor concentrations were the predominant factor influencing personal exposure to volatile organic compounds (including but not limited to benzene, ethylbenzene, hexane, toluene and xylenes).
- Measured outdoor fine Particulate Matter ($PM_{2.5}$) air concentrations were less than the CWS of 30 µg/m^3. $PM_{2.5}$ outdoor concentrations did not play an important role in personal exposure. Instead, the most important exposure source of $PM_{2.5}$ was personal activity and indoor sources.

3.4 ASSESSMENT METHODS

3.4.1 Assessment Cases

In accordance with the AENV TOR (AENV 2008), potential health risks were assessed for the following three assessment cases:

- Existing and Approved Case (EAC): includes potential health risks associated with existing developments and those that have been approved but are not yet operational;
- Project Case: includes potential health risks associated with the EAC as well as the Project; and
- Planned Development Case (PDC): includes potential health risks associated with all of the developments incorporated in the Project Case as well as those developments that were publicly disclosed six months prior to the submission of the EIA.

Volume 2, Table 5-1 lists the developments incorporated in each of the assessment cases.

3.4.2 Temporal Consideration

The development of the Project will occur in two phases. Construction of Phase 3A is anticipated to begin in 2010, with initial steam injection occurring in 2012. Construction of Phase 3B is anticipated to begin in 2012 with initial steam injection in 2014. The Project is expected to operate for 34 years.

The HHRA assessed potential short-term (acute) and long-term (chronic) health risks to people associated with the Chemicals of Potential Concern (COPCs) emitted or released from the Project. The two exposure durations used can be described as follows:

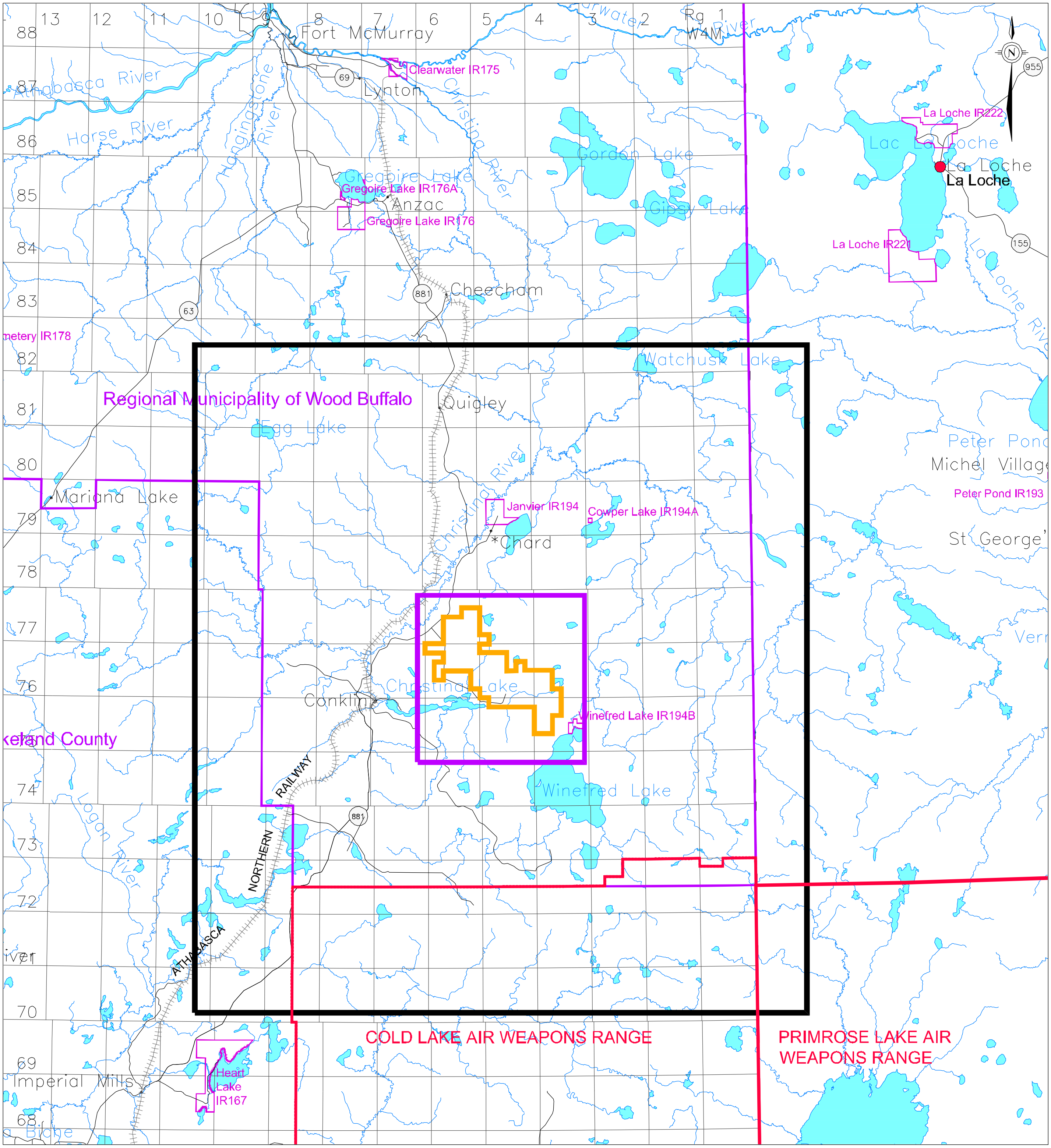
- Acute: exposure extends over a period covering seconds to hours to several days.
- Chronic: exposure occurs continuously or regularly over extended periods, lasting for periods of months through years, and possibly extending over an entire lifetime. This was assumed to extend over a 75-year lifetime (as recommended in Health Canada 2004a).

As such, the temporal scope of the HHRA extended from acute exposure durations in the order of 24 hours or less to chronic exposure durations equivalent to a lifetime. Although the operational life of the Project is only expected to be 27 years, the HHRA assumed that the chemical emissions or releases attributable to the Project would continue for a period of 75 years. This assumption was adopted in the HHRA largely due to the uncertainty surrounding which cumulative sources would be emitting during which periods of time. To be conservative, the air quality model and HHRA assumed that all sources in the area would be emitted simultaneously for the duration of a person's lifespan. This also allowed the HHRA to evaluate a person's potential exposure through all stages of life.

3.4.3 Spatial Considerations

The HHRA for the Project focused on potential health risks to people in the:

- Regional Study Area (RSA): The area over which potential health risks were assessed (Figure 3.4-1). The RSA for the HHRA corresponds to the Air Quality RSA (Section 1, Figure 1.2-1) which encompasses a 110 by 120 km area. The RSA extends into Saskatchewan to ensure that potential risks to Saskatchewan residents were considered and understood.
- Local Study Area (LSA): The area in the immediate vicinity of the Project where the majority of the potential health risks are expected to occur (Figure 3.4-1). The LSA for the HHRA corresponds to the Air Quality LSA (Section 1, Figure 1.2-1) which is defined by an area of approximately 30 by 30 km, encompassing the Project area.



20 0 20

SCALE KILOMETRES

LEGEND

— ROAD
┼┼┼ RAILWAY
— RIVER
🟦 OPEN WATER
▭ INDIAN RESERVE
🟥 COLD LAKE AIR WEAPONS RANGE
▭ MEG LEASE BOUNDARY
▭ HUMAN HEALTH LOCAL STUDY AREA
▭ HUMAN HEALTH REGIONAL STUDY AREA

NOTE

* Also known as the Hamlet of Janvier

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

HUMAN HEALTH STUDY AREAS

MEG ENERGY CORP.

PROJECT	07.1346.0009.8800		FILE No.	HH Study Areas
DESIGN	MS	28/11/07	SCALE AS SHOWN	REV. 0
CADD	TRE	12/02/08		
CHECK	BK	01/04/08		
REVIEW	IGG	01/04/08		

FIGURE: 3.4-1

L:\2007\1346\07-1346-0009-MEG EXPANSION\Vol 3-Section III\Fig 3.4-1 Human Health Study Areas.dwg Apr 04, 2008 - 9:36am

3.4.4 Assessment Methods

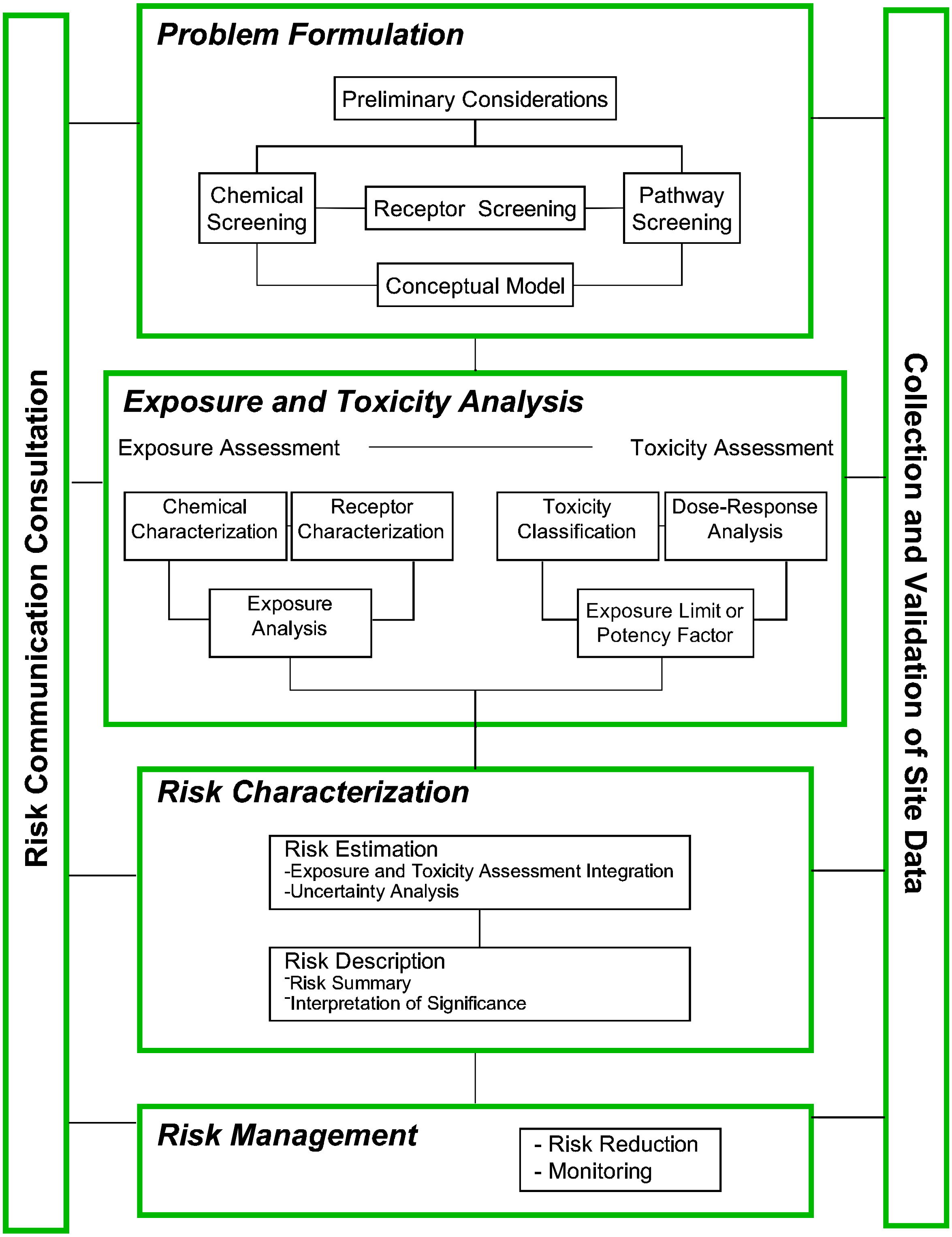
In the current HHRA, potential health risks were examined using a conventional risk assessment paradigm. The risk assessment paradigm is consistent with those developed by Health Canada (2004a), the Canadian Council of Ministers of the Environment (CCME 1996), the U.S. National Research Council (U.S. NRC 1983, 1996) and the U.S. Environmental Protection Agency (U.S. EPA 1991, 2004). This risk assessment methodology has been endorsed by several provincial regulatory authorities in the past, including Alberta Environment, Alberta Health and Wellness, and the Energy Resources Conservation Board (ERCB).

In general, the risk assessment paradigm includes four steps (Figure 3.4-2):

- Problem Formulation: identification of the COPCs associated with the Project emissions, characterization of people potentially “at risk” and determination of the relevant exposure pathways;
- Exposure Assessment: quantification of the potential amount or dose of each COPC received by humans through all relevant exposure pathways;
- Toxicity Assessment: identification of potential adverse health effects associated with each of the COPCs, the conditions under which these effects are observed and determination of the maximum safe dose of the chemical for the most sensitive subjects following exposure for a prescribed period (i.e., identification of acute and chronic exposure limits for COPCs); and
- Risk Characterization: comparison of estimated exposures (determined in the exposure assessment) with exposure limits (established in the toxicity assessment) to identify potential health risks for the different assessment cases, as well as discussion of sources of uncertainty and how these were addressed in the risk assessment.

By convention, the uncertainty associated with the prediction of potential health risks is accommodated, in part, through the use of assumptions which embrace a high degree of conservatism. Using this approach, any health risks identified by the assessment are unlikely to be understated, but may be considerably overstated. Thus, it is important that the uncertainties and assumptions underlying the potential health risks be known and understood. The uncertainties addressed and the assumptions used in the HHRA are documented in Section 3.4.4.4 (Risk Characterization).

Each of these steps is described in detail in the following sections.



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

RISK ASSESSMENT PARADIGM

MEG ENERGY CORP.

PROJECT	07.1346.0009.8800		FILE No. Risk Assess Paradigm
DESIGN	CM	11/02/07	SCALE NTS REV. 0
CADD	TRE	12/02/08	**FIGURE: 3.4-2**
CHECK	BK	01/04/08	
REVIEW	IGG	01/04/08	

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\Vol 3-Section III\Fig 3.4-2_Risk Assessment Paradigm.dwg Apr 04, 2008 - 9:37am Image:MEGcube-R.bmp

3.4.4.1 Problem Formulation

The purpose of the problem formulation is to collect information to further focus the HHRA, as described in detail below:

- Identification of the COPCs – identifying COPCs emitted or released from the Project that might contribute to potential human health risks.
- Characterization of people potentially at risk – identifying people who might be exposed to emissions from the Project, with special consideration given to sensitive and more susceptible individuals (e.g., infants and young children, the elderly, individuals with compromised health).
- Identification of relevant exposure pathways – ensures that applicable exposure pathways are identified, with consideration given to the physical-chemical properties of the COPCs, their fate and transport characteristics and their tendency to persist and concentrate in the environment.

Identification of Chemicals of Potential Concern

The COPCs for the Project were identified through:

- development of an inventory of chemicals that could be emitted or released by the Project;
- review of chemicals identified by stakeholders as being a human health concern;
- determination of whether or not sufficient toxicological information is available to assess potential health risks (i.e., through use of available regulatory “exposure limits”); and
- selection of chemical surrogates to represent any of the compounds for which no suitable exposure limits were available.

Chemical Inventory

The identification of COPCs began with the development of a comprehensive inventory of chemicals that could be emitted or released by the Project to which people may be exposed. The development of the initial chemical inventory considered possible Project air emissions and water releases. Only Project emissions or releases resulting in potential changes to environmental quality were identified in the initial inventory of chemicals.

Air

The Project will use Steam Assisted Gravity Drainage (SAGD) bitumen recovery technology. Continuous sources that will emit chemicals into the air at each phase of the Project include:

- fourteen Once Through Steam Generators (OTSGs) fired on natural gas at each of the two phases;
- two glycol heaters fired on sweetened produced gas at each of the two phases;
- two slop treaters fired on sweetened produced gas at each of the two phases;
- two amine preheaters fired on sweetened produced gas at each of the two phases;
- two flares, each with a natural gas fired pilot running continuously at each of the two phases;
- one Sulphur Recovery Unit (SRU) incinerator; and
- plant fugitives from tank losses as well as leaks from piping and other processing equipment.

As described in the Air Quality Assessment (Section 1), ground-level air concentrations of the emitted chemicals are predicted to increase in the region as a result of the Project. The chemical air emission inventory includes:

- Five federally and provincially regulated contaminants, including Carbon Monoxide (CO), NO_2, O_3, Particulate Matter (PM) and SO_2. Federally regulated contaminants include those compounds for which the permissible levels in ambient air are governed at the federal level in the form of either a National Ambient Air Quality Objective or a Canada Wide Standard.
- 18 Total Reduced Sulphur (TRS) compounds, including carbon disulphide, carbonyl sulphide, hydrogen sulphide, mercaptans and thiophenes.
- 225 Volatile Organic Compounds (VOCs), including aliphatic and aromatic compounds, aldehydes and ketones.
- 46 Polycyclic Aromatic Hydrocarbons (PAHs).
- 15 metals.

Surface Water

According to the Water Quality Assessment (Volume 4, Section 5.3), Project activities are not predicted to influence surface water quality. The following pathways that potentially link Project-related activities and water quality effects were examined as part of the Water Quality Assessment:

- changes in suspended sediments inputs to waterbodies due to surface disturbances during construction at watercourse crossings and changes in runoff;
- changes in groundwater quality;
- changes in stream flows and lake levels due to groundwater withdrawal and changes in runoff;
- changes due to potential leaks and spills; and
- changes from wastewater releases.

After further evaluation, the Water Quality Assessment concluded that most of these potential linkages were invalid, with the exception of potential changes in surface water quality resulting from the discharge of runoff from Project facilities containing suspended sediments, potential spills and wastewater releases.

Prior to discharge, runoff will be tested against regulatory standards. Given the management of runoff waters and the controlled rate of water releases from the stormwater ponds, the effects of releases of runoff waters on surface water quality are predicted to be negligible. Potential effects on water quality as a result of spills will be minimized by management practices, mitigation plans, design features and emergency response procedures. All site facilities and associated pipelines will be constructed to comply with all regulatory guidelines and practices, and pipelines and storage areas will also be inspected and maintained on a routine basis.

Treated wastewater effluent will be tested a minimum of three times per week to ensure the wastewater meets discharge standards. If a sample fails to meet discharge standards, operation of the treatment plant will be stopped until the cause of the failure has been identified and addressed. Given the management of treated effluent and controlled rate of water releases, the effects of wastewater releases to the wetlands area on surface water quality are predicted to be negligible.

As the Water Quality Assessment (Volume 4, Section 5.3) did not predict any effects on surface water quality, chemicals potentially released to surface water from the Project were not included in the inventory of chemicals for the HHRA.

Groundwater

No groundwater and surface water interaction was predicted in the hydrogeology LSA. In addition, due to the Total Dissolved Solids (TDS) concentrations, water in the McMurray Aquifer is not suitable for domestic use, livestock watering, irrigation or most industrial demands. As such, the magnitude of effect on groundwater quality is considered low and would not contribute to human health risks.

Drilling and completion of the SAGD wells and surface facility operations are not expected to affect groundwater quality because management practices, mitigation plans, design features and emergency response procedures will minimize spills. In addition, a groundwater monitoring program will allow for early detection of any changes and the implementation of response measures to minimize the effects of any potential releases.

Given that the heat plumes are predicted to extend less than 325 m from the well bores and that no domestic use or non-saline water wells were identified within 1 km of the wellpads, steam injection is not predicted to affect other groundwater users.

On this basis, possible Project releases to groundwater were not included in the development of the initial inventory of chemicals for the HHRA.

Initial Chemical Inventory

Because potential emissions to surface water and groundwater were determined to be negligible, atmospheric emissions are the only Project emissions assessed in terms of potential human health risks. Thus, the chemical air emissions inventory of almost 300 chemicals compiled in the Air Quality Assessment (Section 1) formed the initial chemical inventory for the identification of the COPCs associated with the Project.

Stakeholder Health Concerns

Through the consultation process and review of previous HHRAs completed in the Oil Sands Region, stakeholders have specifically identified arsenic, mercury and PM as chemicals of concern. All of these chemicals were identified in the HHRA as COPCs requiring further assessment.

Arsenic

Concerns were recently raised regarding the potential health risks associated with measured arsenic levels in the Oil Sands Region. In an attempt to better understand arsenic-related health risks in the area, AHW commissioned a study to investigate the potential lifetime cancer risks that could be presented to people living in the RMWB from arsenic exposure associated with the consumption of wild game and other traditional food items (AHW 2007). The AHW study concluded that "the lifetime cancer risks that could potentially result from exposure to inorganic arsenic among indigenous people living in the Wood Buffalo region are dominated by already existing naturally occurring and anthropogenic sources of arsenic in the region, with very little incremental risk presented by the projected future anthropogenic activities" (AHW 2007). Notwithstanding this conclusion, due to the recent concerns related to arsenic exposures in the Oil Sands Region, arsenic was identified as a COPC in the HHRA.

Mercury

In the past, concern over the potential adverse human health impacts that could result from mercury released from the Project have been documented, especially in relation to the consumption of local fish. Although the Project will not emit methyl mercury directly to the environment, mercury was identified in the initial air emissions inventory which can be bio-transformed to methylated mercury in the sediment and in the water column of local waterbodies. Methylation is the key step in the entrance of mercury into the food chain (U.S. EPA 1997). On this basis, methyl mercury, in addition to mercury, was identified as a COPC for the HHRA.

Particulate Matter

In assessing the potential adverse human health impacts associated with PM, it was assumed that all fine particulate emissions from the Project were in the form of $PM_{2.5}$ because the Project's air emissions will be largely combustion-related. Coarser particulate matter (i.e., greater than PM_{10}) is generated mechanically through agriculture, mining and road traffic (Schwartz et al. 1996). Scientific evidence indicates that $PM_{2.5}$ concentrations are a better predictor of health effects than PM_{10} (WHO 2000, Website). Based on this evidence, it was conservatively assumed that all PM released from the Project consists of $PM_{2.5}$. Thus, potential health risks associated with $PM_{2.5}$ were assessed in the HHRA.

Exposure Limits

Health-based exposure limits developed by scientific and/or regulatory agencies were identified for those chemicals that might be emitted as a result of the Project. The scientific and regulatory agencies consulted included:

- AENV;
- Health Canada and Environment Canada;
- United States Environmental Protection Agency (U.S. EPA);

- World Health Organization (WHO);
- Agency for Toxic Substances and Disease Registry (ATSDR);
- American Conference of Governmental Industrial Hygienists (ACGIH);
- California's Office of Environmental Health Hazard Assessment (OEHHA);
- Canadian Council of Ministers of the Environment (CCME);
- Netherlands National Institute of Public Health and the Environment (RIVM); and
- Ontario Ministry of the Environment (OMOE).

Each exposure limit was reviewed to ensure that the information upon which it was based was relevant and based on adequate supporting documentation. Further details regarding the selection of the health-based exposure limits is provided in Section 3.4.4.3 (Toxicity Assessment) and Appendix 3-VII (Toxicity Profiles). Health-based exposure limits were identified for most of the chemicals listed in the initial chemical inventory. With the exception of ozone, these chemicals were selected as COPCs for the HHRA.

Although ozone is a regulated contaminant in Canada with a 1-hour AAAQO of 82 ppb developed by AENV (2007, Website) and an 8-hour CWS of 65 ppb developed by the federal government under the provisions of the CWS program (CCME 2000a), it was not included as a COPC in the HHRA for the following reasons:

- The maximum 1-hour and 8-hour ozone concentrations measured at the Cold Lake South station were below their respective 1-hour AAAQO and 8-hour CWS guidelines (Section 1).
- Ozone is a secondary contaminant that is formed through the interaction of precursor chemicals, such as nitrogen oxides (NO_x) and VOCs. The Project will not emit ozone directly to the atmosphere; however, it will emit its precursor chemicals. Precursor chemicals will react to form ozone downwind from the Project under specific meteorological conditions (i.e., high solar radiation, high temperature and low wind speed, typically on a hot summer day). It is important to note that whereas some meteorological conditions lead to the reactions that produce ozone, others favour ozone destruction. Also, reactions that create ozone can occur simultaneously with those that destroy ozone.
- According to the Air Quality Assessment (Section 1), Project emissions of ozone precursor chemicals could potentially increase regional emissions by 36.7%. The Ozone Modelling Group predicted that a near doubling of anthropogenic (man-made) NO_X and VOC emissions would increase peak-hourly ozone concentrations by as much as 30 ppb (Earth

Tech and Conor Pacific 1998). On this basis, the Project's estimated increase in ozone precursor emissions could increase peak ozone concentrations in the RSA by approximately 11 ppb, which would not result in exceedances of the 1-hour AAAQO. The Air Quality Assessment also found that in the modelling domain, ozone precursor emissions from the Project could increase ozone concentrations by approximately 0.3 ppb.

- Due to the uncertainty associated with the sources of ozone in northeastern Alberta, the chemical reactions associated with ozone formation and destruction and the possible transport of ozone over long distances, ozone concentrations were not predicted in the Air Quality Assessment (Section 1). As a result, ozone was not identified as a COPC in the HHRA.
- Environment Canada and the Wood Buffalo Environmental Associations (WBEA) are currently conducting ambient monitoring and photochemical modelling of ozone in the Oil Sands Region in an effort to determine the roles that precursor emissions and photochemistry (the effects of light and ultraviolet radiation on chemical reactions) play in contributing to ozone levels in the region.

Surrogates

Surrogate chemicals were used whenever possible to represent those chemicals for which exposure limits could not be identified. This step relied on the toxicological principle that states that the molecular structure of a chemical has a distinct bearing on its reactivity, biological activity and toxicity. The principle allows for the toxicity of a chemical for which little or no toxicological information exists to be predicted on the basis of information available on another chemical of similar molecular structure. The second chemical is termed a "surrogate". For example, a health-based exposure limit for carbonyl sulphide is currently not available, but a health-based exposure limit is available for a suitable surrogate: carbon disulphide. Therefore, carbonyl sulphide was assessed using the exposure limit for carbon disulphide.

Chemicals of Potential Concern

Chemicals of Potential Concern identified for inclusion in the HHRA are listed in Table 3.4-1. Most of the chemicals identified in the initial inventory were assessed either as individual chemicals (e.g., arsenic) or as chemical constituents within a group (e.g., acenaphthylene within the acenaphthenes/acenaphthylenes group). Several COPCs were included both as individual chemicals (e.g., hexane) and as part of an aliphatic or aromatic group (e.g., in this case, the aliphatic C_2-C_8 group). In these instances, the exposure limit identified for the individual chemical was lower (i.e., more conservative) than the exposure limit for the aliphatic or aromatic group as a whole.

Table 3.4-1 Chemicals of Potential Concern Addressed in the Human Health Risk Assessment

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Aliphatic C_2-C_8 group	1,1,3-Trimethylcyclopentane, 1,1-dimethylcyclohexane, 1,1-dimethylcyclopentane, 1,2,3-trimethylcyclopentene, 1,2,4-trimethylcyclopentane, 1,2-dimethylcyclohexane, 1,2-dimethylcyclopentane, 1,3-dimethyl-2-(1-methylene)cyclopentene, 1,3-dimethylcyclopentane, 1,4-dimethylcyclohexane, 1,5-dimethylcyclopentene, 1-ethyl-1-methylcyclopropane, 1-hexene, 1-methyl-1-(2-methylene)cyclopentane, 1-methyl-2-methylene cyclopentane, 1-methyl-4-(1-methylene)cyclohexane, 1-methyl-4-(1-methylethyl)cyclohexane, 1-methyl-4-(methylene)cyclohexane, 1-methyl-4-(methylene)cyclohexene, 1-propyne, 2,2,3-trimethylbutane, 2,2,3-trimethylpentane, 2,2,4-trimethylpentane, 2,2-dimethylbutane, 2,2-dimethylpropane, 2,3,4-trimethylpentane, 2,3-dimethylbutane, 2,3-dimethylhexane, 2,3-dimethylpentane, 2,4-dimethyl-1-pentene, 2,4-dimethylhexane, 2,4-dimethylpentane, 2,5-diethylthiophene, 2,5-dimethyl-1,3-hexadiene, 2,5-dimethylhexane, 2,5-dimethylthiophene, 2-ethyl-1-hexanol, 2-ethyl-2-hexene, 2-ethyl-3-methylcyclopentene, 2-hexene, 2-methyl-1-butene, 2-methyl-1-pentene + 1-hexene, 2-methyl-2-pentene, 2-methyl-3-pentene, 2-methyl-4-pentene, 2-methylbutane, 2-methylbycycloheptane, 2-methylcyclopentane, 2-methylheptane, 2-methylhexane, 2-methylpentane, 2-methylpentane + cyclopentane, 2-octene, 2-propanol, 3,3-dimethyl-1-butene, 3,3-dimethylpentane, 3,4-dimethyl-1-pentene, 3-ethylhexane, 3-methyl-1,3-pentadiene, 3-methyl-1,3-pentadiene(e), 3-methyl-1,3-pentadiene(z), 3-methyl-1-butene, 3-methyl-1-hexene, 3-methyl-2-hexene, 3-methyl-2-pentene, 3-methylcyclopentene, 3-methylene pentane + 2,3-dimethybutane, 3-methylheptane, 3-methylhexane, 3-methylpentane, 4,4-dimethylcyclopentene, 4-methyl-1-(1-methylene)cyclohexene, 4-methyl-3-heptene, 4-methylcyclohexene, 4-methylheptane, 5-methyl-1,4-hexadiene, acetylene + ethane, butane, butene, c-1,2-dimethylcyclohexane, c-1,3-dimethylcyclohexane, c-1,3-dimethylcyclopentane, c-1-butyl-2-methylcyclopropane, cis-2-butene, cis-2-hexene, cyclohexane, cyclohexene, cyclooctane, cyclopentane, ethane, ethylcyclopentane, ethylene, ethyne, heptane, hexane, i-butane	n/a
Aliphatic C_9-C_{16} group	1,1,2,3-Tetramethylcyclohexane, 1,1,2,3-tetramethylcyclopentane, 1,1,3,4-tetramethylcyclopentane, 1,1,3,5-tetramethylcyclohexane, 1,1,3-trimethylcyclohexane, 1,1,4-trimethylcyclohexane, 1,2-diethyl-1-methyl-cyclohexane, 1,3,5-trimethyl-2-octadecylcyclohexane, 1-ethyl-2,3-dimethylcyclohexane, 1-ethyl-2,4-dimethylcyclohexane, 1-ethyl-2-propyl cyclohexane, 1-pentyl-2-propylcyclopentane, 2,2,5-trimethylhexane, 2,2,7-trimethyl-3-octyne, 2,2-dimethyl-3-decene, 2,2-dimethyl-3-octyne, 2,3,4-trimethylhexane, 2,3-dimethyloctane, 2,4-diethyl-1-methylcyclohexane, 2,5,5-trimethyl-1,6-heptadiene, 2,5,5-trimethyl-1-hexene, 2,6,10-trimethyltridecane, 2,6-dimethyl-2-octene, 2,6-dimethyl-4-octene, 2,6-dimethylheptane, 2,4-methyloctane, 2-methyl-4,5-nonadiene, 2-methyloctyne, 3,3,4-trimethylhexane, 3,3,4-trimethylcyclohexene, 3,3,8-trimethyldecane, 3,7,7-trimethyl bicycloheptane, 3,7-dimethyl-1-octene, 3-dodecene, 3-ethyl-2-methyl-1,3-hexadiene, 3-ethyl-2-methyl-2-heptene, 3-ethyl-3-octene, 3-methyloctane, 4,8-dimethyl-1,7-nonadiene, 4-ethyloctane, 4-methyl-2,7-octadiene, 4-methyloctane, 5-eicosyne, 7-methyl-5-undecene, amorphane, bicyclononane, butylidenecyclohexane, decane, decylcyclohexane, ethylidenecycloheptane, farnesane, heptylcyclohexane, hexadecane, hexylcyclohexane, isocamphase, n-decane, n-dodecane, n-hexadecane, n-nonane, nonane, nonylcyclohexane, norfarnesane, n-pentadecane, n-tetradecane, n-tridecane, octahydropentalene, octylcyclohexane, pentylcyclohexane, tetradecane, tridecane	n/a

Table 3.4-1 Chemicals of Potential Concern Addressed in the Human Health Risk Assessment (continued)

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Aliphatic C_{17}-C_{34} group	8b,13a-Dimethyl-14b-n-butylpodocarpane, dodecylcyclohexane, n-eicosane, n-heneicosane, n-heptadecane, n-nonadecane, n-octadecane, norpristane, pentadecylcyclohexane, phytane, pristane, tetradecylcyclohexane, tridecylcyclohexane, undecylcyclohexane	n/a
Aromatic C_9-C_{16} group	Acenaphthenes/acenaphthylenes: Acenaphthene, acenaphthylene, acephenanthrylene Anthrancenes/phenanthrenes and substituted:1-Methylphenanthrene, 2-methylanthracene, 2-methylphenanthrene, 3-methylphenanthrene, 4-methylphenanthrene, 9-methylphenanthrene, anthracene, phenanthrene, retene Aromatic C_9-C_{16}: 2,3-Dimethylbenzaldehyde, 2-ethyl-toluene, 3-ethyl-toluene, 4-ethyl-toluene, cumene, fluorenone, indanone, i-isopropylbenzene, methylpropylbenzene, n-ethyltoluene, n-butylbenzene, n-decylbenzene, n-hexylbenzene, n-octylbenzene, n-propylbenzene, p-cymene, p-ethyltoluene, propylbenzene, xanthone Fluorenes/fluoranthenes and substituted: 2-Methylfluorene, 3-methyldibenzothiophene, 4-methyldibenzothiophene, dibenzothiophene, fluoranthene, fluorene Naphthalenes and substituted: 1-Methylnaphthalene, 2-methylnaphthalene, naphthalene, indole Trimethylbenzenes: 1,2,3-Trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene	n/a
Aromatic C_{17}-C_{34} group	Pyrenes and substituted: 2-Methylpyrene, picene, pyrene (Carcinogenic PAH group 1-3 on an acute basis only)	n/a
Arsenic	Arsenic	n/a
Barium	Barium	n/a
Benzene	Benzene	n/a
Beryllium	Beryllium	n/a
Cadmium	Cadmium	n/a
Carbon disulphide group	Carbon disulphide, carbonyl sulphide	Carbon disulphide
Carbon monoxide	Carbon monoxide	n/a
Carcinogenic PAH group 1	Benzo(a)pyrene, benzo(e)pyrene, dibenz(a,h)anthracene, 1-nitropyrene	Benzo(a)pyrene
Carcinogenic PAH group 2	3-Methylcholanthrene, 7,12-dimethylbenz(a)anthracene, benz(a)anthracene, benzo(a)fluorene, benzo(b)fluoranthene, benzo(g,h,i)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, cyclopenta(c,d)pyrene, indeno(1,2,3-cd)fluoranthene, indeno(1,2,3-cd)pyrene, indeno(1,2,3-w)pyrene	Benzo(b)fluoranthene
Carcinogenic PAH group 3	Carbazole, chrysene, coronene, perylene, benzo(g,h,i)perylene, benzo(g,h,i)perylene	Chrysene
Chromium	Chromium	n/a
Chromium VI(a)	Chromium VI	n/a
Cobalt	Cobalt	n/a
Copper	Copper	n/a
Ethylbenzene	Ethylbenzene	n/a
Ethylene	Ethylene	n/a
Formaldehyde	Formaldehyde	n/a
Hexane group	1-Hexene, 2,3-dimethylhexane, 2,4-dimethylhexane, 2,5-dimethyl-1,3-hexadiene, 2,5-dimethylhexane, 2-ethyl-1-hexene, 2-hexene, 2-methylhexane, 3-ethylhexane, 3-methyl-1-butene, 3-methyl-1-hexene, 3-methyl-2-hexene, 3-methylhexane, cis-2-hexene, hexane, n-hexane, trans-2-hexene	Hexane
Hydrogen sulphide	Hydrogen sulphide	n/a
Lead	Lead	n/a
Manganese	Manganese	n/a
Mercury	Mercury	n/a

Table 3.4-1 Chemicals of Potential Concern Addressed in the Human Health Risk Assessment (continued)

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Methyl ethyl ketone group	3-Buten-2-one, acetone, butanone, camphor, methyl ethyl ketone, valencane	Methyl ethyl ketone
Methyl mercury [(b)]	Methyl mercury	n/a
Molybdenum	Molybdenum	n/a
Naphthalene group	1-Methylnaphthalene, 2-methylnaphthalene, naphthalene, indole	Naphthalene
Nickel	Nickel	n/a
Nitrogen dioxide	Nitrogen dioxide	n/a
$PM_{2.5}$ [(c)]	$PM_{2.5}$	n/a
Selenium	Selenium	n/a
Sulphur dioxide	Sulphur dioxide	n/a
Toluene	Toluene	n/a
Trimethylbenzenes	1,2,3-Trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene	1,2,4-Trimethylbenzene
Vanadium	Vanadium	n/a
Xylenes	m-Xylene, o-xylene, p-xylene, xylene	n/a
Zinc	Zinc	n/a

(a) Chromium VI was assumed to represent 10% of total chromium (CARB 1985). For further details, see Appendix 3-VII (Toxicity Profiles).

(b) Methyl mercury, although not included in the air emissions inventory, was included as a COPC in the HHRA because mercury emitted from the Project can be methylated in local waterbodies.

(c) $PM_{2.5}$ includes both primary and secondary particulates.

n/a = Not applicable; a surrogate chemical was not required.

Most of the chemicals listed in the initial inventory were retained as COPCs for the HHRA. The only chemicals not retained from the initial inventory due to a lack of health-based exposure limits and applicable surrogates were:

- ozone (for reasons discussed above);
- eight alkylated mercaptans, including amyl mercaptan, butyl mercaptan, ethyl mercaptan, isobutyl mercaptan, isopropyl mercaptan, methyl mercaptan, propyl mercaptan and tert-butyl mercaptan; and
- seven alkylated thiophenes, including 1,3-dimethyl thiophene, 2,3-dimethyl thiophene, 2,5-dimethyl thiophene, 2-ethyl thiophene, 2-methyl thiophene, 3-methyl thiophene and thiophene.

Characterization of People Potentially at Risk

The individuals in the region that have the highest potential health risks associated with Project emissions include those who may receive the highest exposures to the emissions and those who may be more sensitive or susceptible to potential Project emissions. In this regard, consideration was given to:

- the people that are known or anticipated to spend time near the Project;

- the physical characteristics of the people in the region that could result in increased exposure;
- the lifestyles of the individuals in the region that could result in increased exposure (e.g., consumption patterns, portion of diet obtained locally); and
- sensitive or more susceptible individuals in the region (e.g., infants and young children, the elderly, individuals with compromised health).

Additional details regarding characterization of people potentially at risk from the Project emissions and releases are provided below and in Appendix 3-VIII (Multiple Pathway Exposure Model and Predicted Exposure Point Concentrations).

Locations at Which People Reside or Visit

The HHRA recognizes that people may use the area near the Project for recreational or traditional activities, such as hunting, trapping or gathering plants. An assessment of the potential adverse health risks to people active along the boundary of the Project area, specifically, at locations along the fence-line for which the highest ground-level air concentrations of the COPCs were predicted to occur was conducted. It is important to note that access to the immediate Project area will be managed by MEG. Thus, the location along the Project area boundary was selected to represent the maximum potential health risks attributable to the Project for any individuals who may be present at locations within the immediate vicinity of the Project site. For the HHRA, these locations were considered to be equivalent to the Maximum Point of Impingement (MPOI).

Outside the Project area, but still within the LSA, a location importance to First Nations groups was identified (i.e., Chipewyan Prairie Dene First Nation, Winefred Lake Reserve). This reserve is located southeast of the Project and includes trapper’s cabins, campsites and generally supports a number of traditional land uses. In addition to this location, two cabins along the Project lease boundary were identified. These cabins (i.e., Hunter/Trapper A and Hunter/Trapper B) could be used by people engaged in traditional activities in the area. The Operator’s Residence is also located within the LSA where maximum Project-related changes in environmental quality are expected to occur. As such, the people that spend time or reside at each of these discrete locations were characterized as being at potential risk of adverse health impacts attributable to the Project and were thus included in the HHRA.

Outside the LSA, but still within the RSA, two nearby communities in Alberta (i.e., Conklin and Janvier/Chard) and the Christina Lake Lodge were also identified. Although even further removed from the Project (located outside the RSA), residents of La Loche, Saskatchewan were included in the HHRA to ensure that maximum potential health risks to people living outside of Alberta were considered and understood.

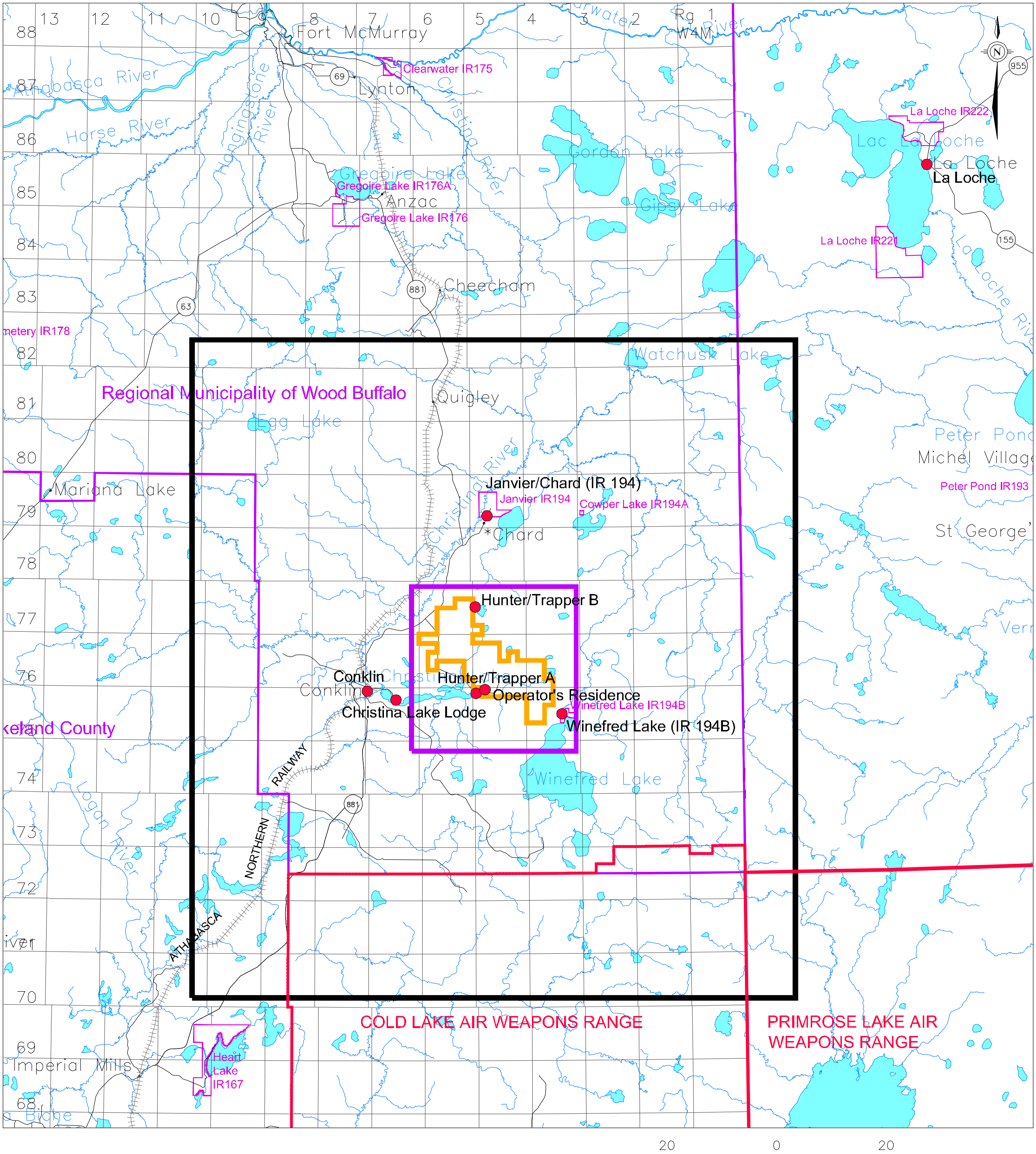
A total of nine locations where people are known or anticipated to spend time were included in the HHRA. These locations are listed below and shown in relation to the Project and the HHRA study areas in Figure 3.4-3:

- MPOI;
- Conklin;
- Janvier/Chard (IR 194);
- Winefred Lake (IR 194B);
- Hunter/Trapper A;
- Hunter/Trapper B;
- Operator’s Residence (MEG House);
- Christina Lake Lodge; and
- La Loche, Saskatchewan.

Physical Characteristics of People in the Region

Persons that reside at or visit these locations will include members of the general population. Thus, when considering multiple pathways of exposure on a long-term basis, it is important to consider all age classes or life stages of the people at these locations. Special consideration was given to sensitive and more susceptible life stages (e.g., infants and young children, elderly). The five receptor life stages that were included in the HHRA are consistent with Health Canada guidance (Health Canada 2004a):

- infant (0 to 6 months – 0.5 years);
- toddler (7 months to 4 years – 4.5 years);
- child (5 to 11 years – 7 years);
- adolescent (12 to 19 years – 8 years); and
- adult (20 to 75 years – 56 years).



LEGEND

- ROAD
- RAILWAY
- RIVER
- OPEN WATER
- INDIAN RESERVE
- COLD LAKE AIR WEAPONS RANGE
- ● LOCATIONS OF SELECTED RECEPTORS IN THE RSA
- MEG LEASE BOUNDARY
- HUMAN HEALTH LOCAL STUDY AREA
- HUMAN HEALTH REGIONAL STUDY AREA

NOTE

* Also known as the Hamlet of Janvier

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.

PROJECT
CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE
RECEPTOR LOCATIONS TO BE USED IN THE HUMAN HEALTH RISK ASSESSMENT

MEG ENERGY CORP.

PROJECT	07.1346.0009.8000	
DESIGN	MS	28/11/07
CADD	TRE	12/02/08
CHECK	BK	01/04/08
REVIEW	IGG	01/04/08

FILE No. Receptor Locations...
SCALE AS SHOWN REV. 0

FIGURE: 3.4-3

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\Vol 3-Section III\Fig 3.4-3 Receptor Locations-Human Health Risk Assessment.dwg Apr 04, 2008 - 9:38am

For the assessment of carcinogens, a "composite individual" who represents all life stages (e.g., from infant to adult) was used to represent cumulative exposure over a 75-year lifetime.

General physical characteristics of typical Canadians at each life stage were obtained from documents published by Health Canada (2004a), CCME (2006), U.S. EPA (1997) and O'Connor and Richardson (1997). The physical characteristics used in the HHRA are summarized in Table 3.4-2.

Table 3.4-2 Assumed Physical Characteristics of the People in the Region

Physical Characteristic[a]	Life Stage					Source
	Infant	Toddler	Child	Adolescent	Adult	
Body weight [kg]	8.2	16.5	32.9	59.7	70.7	Health Canada (2004a)
Inhalation rate [m^3/d]	2.1	9.3	14.5	15.8	15.8	Health Canada (2004a)
Soil ingestion rate [g/d]	0.02	0.08	0.02	0.02	0.02	Health Canada (2004a)
Water ingestion rate [L/d]	0.3	0.6	0.8	1.0	1.5	Health Canada (2004a)
Arms and legs body surface area [cm^2]	1,460	2,580	4,550	7,200	8,200	Health Canada (2004a)
Hand surface area [cm^2]	320	430	590	800	890	Health Canada (2004a)
Soil adherence factor [g/m^2/d]	0.1	0.1	0.1	0.1	0.1	CCME (2006); Health Canada (2004a)
Soil adherence factor – hands only [g/m^2/d]	1	1	1	1	1	CCME (2006)

[a] Food consumption rates are described in the following section.

Lifestyles of People in the Region

Based on the location at which individuals were determined to reside or visit, people were assigned to one of the following lifestyle categories:

- Transient persons: includes all occasional or seasonal visitors to the immediate vicinity of the Project for recreational or traditional activities such as hunting, trapping and plant gathering.
- Aboriginal Residents: includes all individuals that use the cabins located near the Project as temporary residences while engaged in traditional activities and all permanent residents of neighbouring Aboriginal communities. Christina Lake Lodge was included in this group as individuals engaged in traditional activities could use this location as a temporary residence.
- Community Residents: includes all permanent residents of Conklin, Operator's Residence and La Loche, Saskatchewan.

The primary differences between these lifestyle categories are the frequency and amounts of various food items consumed. Individuals within each lifestyle category were assumed to share common behavioural characteristics, such as time spent in the area, dietary consumption patterns and the proportion of foods obtained locally, that would result in similar levels of exposure. The person with the highest predicted exposure of each lifestyle category was assumed to represent the potential health risks for all of the people included in the particular lifestyle category. For example, on an acute inhalation basis, the residents of Janvier/Chard (IR 194) were typically predicted to be the highest exposed of the five populations categorized as Aboriginal residents. As such, the potential health risks predicted for the population of Janvier/Chard (IR 194) were assumed to be the "reasonable worst case" health risks for the lifestyle category as a whole.

The locations included in each lifestyle category are shown in Table 3.4-3.

Table 3.4-3 Land Use Groups and Corresponding Locations

Lifestyle Category	Count	Location
transient person	1	MPOI
Aboriginal resident	5	Janvier/Chard (IR 194), Winefred Lake (IR 194B), Hunter/Trapper A, Hunter/Trapper B and Christina Lake Lodge
community resident	3	Conklin, Operator's Residence and La Loche, Saskatchewan

Transient Persons

The HHRA assumed that transient persons could be situated at the fence-line MPOI for periods of 24 hours or less. Due to the short-term nature of their potential exposure to the COPCs at these locations, transient persons were assessed on an acute basis only.

Transient persons were assumed to reside at one of the nearby cabins or communities. Thus, potential chronic health risks to transient persons associated with the ingestion of local wild game, vegetation and surface water obtained during hunting and gathering near the Project were captured as part of these alternate lifestyle categories (i.e., Aboriginal and community residents).

Aboriginal and Community Residents

Although people would likely only occupy the cabins and Christina Lake Lodge during traditional or recreational activities, the actual time spent at these locations could not be definitively determined. As such, it was assumed that people would maintain permanent residency at the cabins, Christina Lake Lodge and residences within the neighbouring communities for their entire lifetimes (i.e., 24 hours per day, seven days per week, 52 weeks per year for 75 years). Aboriginal and community residents were assessed on both an acute and chronic basis.

In addition, it was assumed that Aboriginal residents would obtain all (100%) of their food from local, natural food sources (e.g., wild game, fish, berries and plants). It was assumed that community residents obtain all (100%) of their wild game and fish from local, natural food sources. Based on CCME (2006), it was assumed community residents would obtain 10% of their fruits and vegetables from local, natural food sources. Consumption rates for wild game were based on Health Canada's food ingestion rates for Canadian First Nations populations in combination with the frequency of consumption reported for Native Canadians near Wood Buffalo National Park (WBNP) by Wein (1989). For example, Health Canada (2004a) provides an adult ingestion rate of 270 grams per day of wild game. According to Wein (1989), large mammals make up 76% of the wild game consumed by the 120 Native households interviewed, small mammals make up 16% and upland birds make up 8%. From this, it was assumed that adults would consume 205 grams of moose per day, 43 grams of snowshoe hare per day and 22 grams of ruffed grouse per day. Wild game consumption rates for all life stages are summarized in Table 3.4-4 and Table 3.4-5 for the Aboriginal and community residents, respectively.

Similarly, fish consumption rates for the Aboriginal and community residents were obtained from Health Canada's fish ingestion rates for Canadian First Nations populations (Health Canada 2004a) and were adjusted with frequency of consumption reported by Fort McKay Environmental Services Ltd. (FMES) for the community of Fort McKay (FMES 1996). The FMES reported that people aged 19 to 54 years consume fish, including whitefish, northern pike, trout, grayling, walleye, yellow perch, lingcod, gold eye and sucker, 85 days of the year. This equates to a frequency of 23% (i.e., 85 days of 365 days). On this basis, the Health Canada fish ingestion rate of 220 grams per day for an adult was adjusted to a value of 51 grams per day that is specific to the Fort McKay area (AHW 2007). Similar fish consumption rates have been reported in the 1997 diet and activity survey conducted in Swan Hills by AHW, where the "medium consumer" was reported to ingest 47 grams of fish per day (AHW 1997). Assumed fish consumption rates for all life stages are listed in Table 3.4-4 and Table 3.4-5 for the Aboriginal and community residents, respectively.

Table 3.4-4 Local Food Consumption Rates for the Aboriginal Residents

Food Type	Life Stage Consumption Rate [g/d]					Source
	Infant	Toddler	Child	Adolescent	Adult	
large game (i.e., moose)	0	65	95	133	205	Health Canada (2004a); Wein (1989)
small game (i.e., snowshoe hare)	0	14	20	28	43	Health Canada (2004a); Wein (1989)
game birds (i.e., ruffed grouse)	0	7	10	14	22	Health Canada (2004a); Wein (1989)
fish	0	22	40	47	51	Health Canada (2004a); FMES (1996); AHW (2007)
fruit	3	5	11	19	23	Wein (1989); AHW (2007)
cattail root	0.4	1	1	3	3	Wein (1989); AHW (2007)
wild mint and Labrador tea leaves	0.4	1	1	3	3	Wein (1989); AHW (2007)
breast milk	664	0	0	0	0	O'Connor and Richardson (1997)

Table 3.4-5 Local Food Consumption Rates for the Community Residents

Food Type	Life Stage Consumption Rate [g/d]					Source
	Infant	Toddler	Child	Adolescent	Adult	
large game (i.e., moose)	0	65	95	133	205	Health Canada (2004a); Wein (1989)
small game (i.e., snowshoe hare)	0	14	20	28	43	Health Canada (2004a); Wein (1989)
game birds (i.e., ruffed grouse)	0	7	10	14	22	Health Canada (2004a); Wein (1989)
fish	0	22	40	47	51	Health Canada (2004a); FMES (1996); AHW (2007)
fruit	0.3	0.5	1.1	1.9	2.3	Wein (1989); AHW (2007); CCME (2006)
root vegetables	8.3	10.5	16.1	22.7	18.8	Health Canada (2004a); CCME (2006)
leafy vegetables	7.2	6.7	9.8	12.0	13.7	Health Canada (2004a); CCME (2006)
breast milk	664	0	0	0	0	O'Connor and Richardson (1997)

Fruit consumption rates for the Aboriginal and community residents were based on the food consumption survey conducted near WBNP by Wein (1989). A fruit consumption rate of 134 grams per day reported for Aboriginal people in a Nutrition Canada survey was adjusted to reflect the frequency of berry consumption by local Aboriginal Canadians. In the 120 Aboriginal households interviewed by Wein, berries were reportedly eaten 63 days of the year, which equates to a frequency of 17% (i.e., 63 days in 365 days). On this basis, it was assumed that adult Aboriginal residents would ingest 23 grams of berries per day

(AHW 2007). As it was assumed that community residents obtained 10% of their fruit from local sources, a consumption rate of 2.3 grams of berries per day was assumed for the adult community residents. Fruit consumption rates for all life stages are listed in Table 3.4-4 and Table 3.4-5 for the Aboriginal and community residents, respectively.

For the Aboriginal residents, plant consumption rates were based upon the use of traditional above-ground plants (e.g., wild mint and Labrador tea leaves) and below-ground plants (e.g., cattail root). The consumption rate of 134 grams per day was adjusted by the frequency at which wild mint and Labrador tea leaves were reportedly consumed in the Aborigianl households interviewed by Wein (1989). This adjustment results in an assumed consumption frequency of 2% (i.e., 7 days of 365 days). An adult consumption rate of 3 grams per day was assumed for the Aboriginal residents. Plant consumption rates for all life stages are listed in Table 3.4-4.

Plant consumption rates for the community residents were based on Health Canada's vegetable ingestion rates for the Canadian general population (Health Canada 2004a). The consumption rates were adjusted to reflect the assumption that 10% of their vegetables were obtained from local, natural sources as a large portion of their vegetables would be purchased at the supermarket (90%) (CCME 2006). For example, the Health Canada (2004a) adult ingestion rate of 188 grams of root vegetables per day was adjusted to a consumption rate of 18.8 grams per day to reflect the portion grown locally. Vegetable consumption rates for all life stages are listed in Table 3.4-5.

Another difference between the Aboriginal and community residents is the source of drinking water used by each group. Aboriginal residents were assumed to drink water from local surface waterbodies, while community residents were assumed to have access to a municipal water supply (i.e., Conklin water treatment plant).

Sensitive or Susceptible Individuals

Sensitive and susceptible individuals were addressed through the use of health-based exposure limits developed by leading scientific authorities and regulatory agencies as objectives, guidelines or standards for the protection of air quality and human health (Section 3.4.4.3, Toxicity Assessment). These objectives and guidelines are typically based on highly conservative assumptions, as the mandate of the authorities is to offer guidance aimed at the protection of all persons. Health Canada and other regulatory agencies generally apply a minimum uncertainty factor of 10 in the derivation of their exposure limits to account for the variation in the general population and to protect sensitive subpopulations (e.g., elderly, children) (Health Canada 1994).

Identification of Relevant Exposure Pathways

For chemical exposure to take place, a feasible route of exposure must exist through environmental media and be relevant to that receptor. The potential exposure pathways were based on the previously described lifestyles:

- transient persons;
- Aboriginal residents; and
- community residents.

Because it was assumed that transient persons would only be near the Project on a short-term (acute) basis, inhalation of the COPCs emitted from the Project to the air was deemed to be the only applicable pathway of exposure.

For the Aboriginal and community residents who were assumed to reside in the area on a long-term basis, potential exposures to the COPCs through multiple pathways (i.e., inhalation, ingestion and dermal) were considered. These include:

- inhalation of air;
- inhalation of dust;
- ingestion of soil;
- ingestion of water;
- ingestion of local fruit;
- ingestion of local vegetables (root and leaf);
- ingestion of local fish;
- ingestion of local wild game (moose, snowshoe hare and ruffed grouse); and
- dermal contact with soil.

The Aboriginal and community receptors were assumed to be exposed through all of the above-listed pathways based on the assumption that these individuals live in the area over a 75-year lifetime and consume local drinking water and foods.

Visual descriptions of the exposure pathways relevant to the Aboriginal and community receptors are provided in Figure 3.4-4. Please refer to Appendix 3-VIII (Multiple Pathway Exposure Model and Predicted Exposure Point Concentrations) for information related to the modelling of multiple pathways of exposure.

Table 3.4-6 presents a summary of the exposure pathways in relation to each lifestyle category.

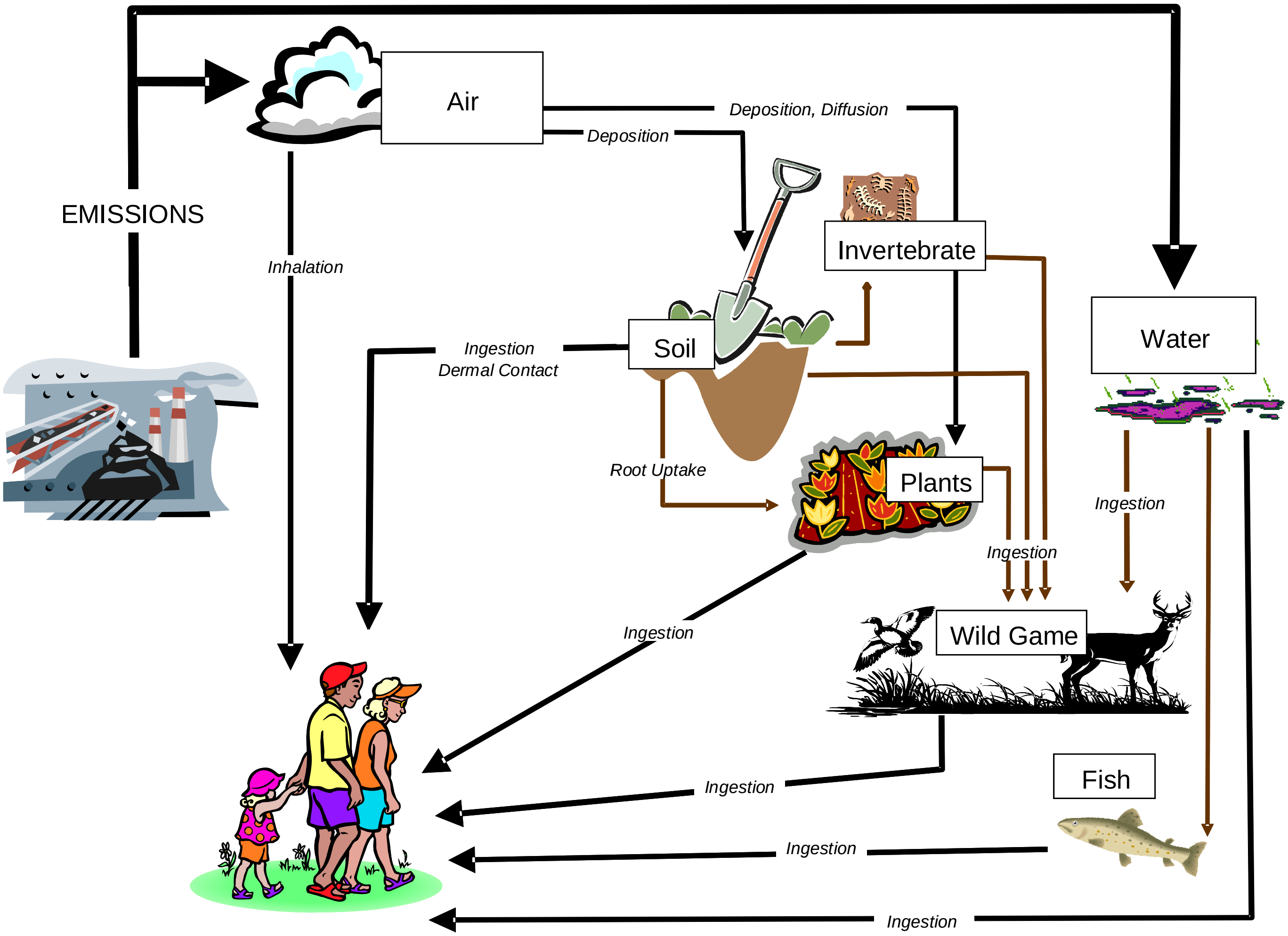
Table 3.4-6 Exposure Pathways Assessed for the Lifestyle Categories

Exposure Pathway	Lifestyle Categories		
	Transient Persons	Aboriginal Residents	Community Residents
Inhalation			
inhalation of air	✓	✓	✓
inhalation of dust	x	✓	✓
Ingestion			
ingestion of soil (inadvertent)	x	✓	✓
ingestion of water[(a)]	x	✓	✓
ingestion of local, country foods (i.e., fruits and vegetables)	x	x	✓
ingestion of local, natural foods (i.e., berries, cattail roots and tea leaves)	x	✓	✓
ingestion of local fish	x	✓	✓
ingestion of local wild game	x	✓	✓
Dermal Contact			
dermal contact with soil	x	✓	✓

(a) Although drinking water ingestion was considered for the Aboriginal and community residents, the source of drinking water differed between the two lifestyle categories. It was assumed that Aboriginal residents would drink from local surface water, while community residents would have access to the municipal water supply from the Conklin water treatment plant (WBEA 2007).

✓ Exposure pathway is applicable for the lifestyle category.

x Exposure pathway is not applicable for the lifestyle category.



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXPOSURE PATHWAYS FOR THE ABORIGINAL AND COMMUNITY RESIDENTS

MEG ENERGY CORP.

PROJECT	07.1346.0009.8800		FILE No.	Exposure-Cabin-FN
DESIGN	CNM	25/10/07	SCALE NTS	REV. 0
CADD	TRE	12/02/08	**FIGURE: 3.4-4**	
CHECK	BK	01/04/08		
REVIEW	IGG	01/04/08		

3.4.4.2 Exposure Assessment

For exposure to take place (and potential health risks to occur), one or more exposure pathways must exist from the point of release of the COPCs into the environment (i.e., from the Project) to the point of contact with humans (Health Canada 1995; U.S. EPA 2002).

The Project will emit COPCs directly into air from various sources, thus people residing near the Project, as well as people visiting the area could be directly exposed to the COPCs via inhalation. All of the COPCs emitted to air were incorporated in the inhalation assessment, discussed in detail in the following section. This includes all of the COPCs identified in the HHRA, with the exception of methyl mercury, which was not identified in the air emissions inventory but can form through the methylation of inorganic mercury species in waterbodies and certain plants.

In addition to the primary pathway of exposure discussed above (i.e., inhalation), people who live in the area may be exposed to the COPCs via secondary exposure pathways. For example:

- Deposition of some COPCs emitted to the atmosphere will occur surrounding the Project and a portion of this deposition will be taken up by the soils. Depending on physical and chemical characteristics of each COPC, chemical deposition could affect the chemical concentrations in local soil. Exposure through inhalation of dust, inadvertent ingestion of soil and dermal contact with soil were included in the HHRA.
- The COPC concentrations in plants could be affected by both the direct deposition of atmospheric emissions onto plant surfaces and uptake of COPCs from soils via roots. Exposure through ingestion of local fruits and vegetables (root and leafy) was included in the HHRA.
- The COPC concentrations in the tissue of local wild game could be affected by both the direct inhalation of the atmospheric emissions and, depending on the fate, transport and persistence of the COPC in the environment, the ingestion of the COPCs in local soil, soil invertebrates, water and vegetation. Exposure through ingestion of local wild game was included in the HHRA.

Although concentrations of the COPCs in local surface water and subsequently fish tissue were not predicted to change as a result of Project emissions, some COPCs were measured in water and fish collected from local surface waterbodies. On this basis, exposure through ingestion of local surface water

(Aboriginal residents only, as community residents are assumed to have access to treated drinking water) and fish were included in the HHRA.

These secondary pathways were incorporated into the multiple pathway assessment. Thus, it was necessary to identify those COPCs that, although only emitted into air, would be likely to persist or accumulate in the terrestrial environment in sufficient quantities for residents to be exposed via secondary pathways. For this purpose, the list of COPCs may be divided into two general categories:

- Gaseous COPCs (i.e., CO, hydrogen sulphide [H_2S], NO_2 and SO_2), which, due to their volatile nature, are not likely to contribute to human exposure via secondary pathways. Thus, it is very unlikely that any of the gaseous COPCs emitted to air would deposit near the Project and contribute to human exposure via secondary pathways. As well, the potential health effects caused by these compounds are associated with inhalation only as they primarily act at the point of contact (i.e., respiratory system). As such, these compounds were not included in the fate and persistence screening.
- Non-gaseous COPCs (i.e., TRS compounds other than H_2S, VOCs, PAHs and metals), which might be deposited near the Project and persist or accumulate in the environment in sufficient quantities for residents to be exposed via secondary pathways.

Based on the typical physical-chemical properties of some of the non-gaseous PAHs and metals, it is likely that these COPCs will be deposited in the environment and will likely persist or accumulate in the environment at least to some extent. On this basis, PAHs and metals were included in the multiple pathway assessment.

To identify the other non-gaseous COPCs that could persist or accumulate in the terrestrial environment, consideration was given to the inherent physical-chemical properties of the COPCs that influence their fate and persistence in the environment and subsequently their potential occurrence in the secondary pathways of exposure.

Given the high degree of variation in the physical-chemical properties of the TRS compounds and VOCs, the fate and persistence of these COPCs could not be determined for the chemical categories as a whole. As such, the physical-chemical properties of each of the TRS compounds (with the exception of H_2S) and VOCs were compared against accepted national and international criteria for the classification of persistent, bio-accumulative substances (Environment Canada 2008; Rodan et al. 1999).

The criteria are listed below:

- half-life in soil more than or equal to 6 months or 182 days; and
- octanol-water partition coefficient (Log K_{ow}) more than or equal to 5.

This exercise is based on the premise that if a chemical does not meet any of the criteria, the chemical is unlikely to accumulate to appreciable amounts in food items or to persist in the environment and therefore the multiple pathway assessment is not applicable. However, if a chemical meets any of the criteria, sufficient opportunity could be presented for exposure to occur via secondary pathways.

The non-gaseous substances (other than metals and PAHs) that could persist or accumulate in the terrestrial environment are identified in Table 3.4-7.

The findings of the exercise indicate that the following COPCs, in addition to the PAHs and metals, could contribute to human exposure via secondary pathways:

- aliphatic C_2-C_8 group;
- aliphatic C_9-C_{16} group;
- aliphatic C_{17}-C_{34} group;
- aromatic C_9-C_{16} group; and
- aromatic C_{17}-C_{34} group.

These specific COPCs were included in the multiple pathway assessment.

All COPCs assessed in the inhalation and multiple pathway assessments are provided in Table 3.4-8.

Table 3.4-7 Identification of Persistent Total Reduced Sulphur Compounds and Volatile Organic Compounds for Inclusion in the Multiple Pathway Assessment

Chemicals of Potential Concern[(a)(b)]	Criteria[(c)]		Inclusion in Multiple Pathway Assessment[(f)]
	Soil Half-Life[(d)] [days]	Log K_{ow}[(e)]	
Aliphatic C_2-C_8 group	712	3.81	✓
Aliphatic C_9-C_{16} group	1,750	6.91	✓
Aliphatic C_{17}-C_{34} group	–	10.3	✓
Aromatic C_9-C_{16} group	1,750	3.91	✓
Aromatic C_{17}-C_{34} group	1,400	6.42	✓
Benzene	23	2.1	x
Carbon disulphide group	–	0.80	x
Ethylbenzene	10	3.1	x
Ethylene	–	1.13	x
Formaldehyde	7	0.35	x
Hexane group	–	3	x
Methyl ethyl ketone group	7	3.58	x
Toluene	22	2.7	x
Trimethylbenzenes	–	3.42	x
Xylenes	28	3.2	x
Criteria	**182**	**5**	

(a) By their very nature, gaseous COPCs (i.e., CO, H_2S, NO_2 and SO_2) will remain airborne for extended times and over extended distances; thus, the likelihood that any of the gaseous chemicals emitted to air would deposit near the Project and be available for exposure via secondary pathways is low. On this basis, gaseous COPCs were not included in the multiple pathway assessment.

(b) By their very nature, PAHs and metals will deposit near the Project and persist or accumulate in the environment, presenting sufficient opportunity for exposure via secondary pathways. On this basis, PAHs and metals were included in the multiple pathway assessment and were not screened in this table.

(c) Criteria for the chemical groups were based on the highest criteria of the group's individual constituents.

(d) Taken from Mackay et al. (1992) and U.S. EPA OSW (2005). Exceptions are benzene which was cited from Wania and Mackay (2000) and the aliphatic and aromatic groups which were cited from CCME (2000b).

(e) Taken from Mackay et al. (1992), U.S. EPA OSW (2005) and HSDB (2007, Website). Exceptions are the aliphatic and aromatic groups which were cited from CCME (2000b).

(f) The COPCs that meet any one of the criteria could present sufficient opportunity for exposure via secondary pathways.

✓ COPC was included in the multiple pathway assessment.

x COPC was not included in the multiple pathway assessment.

– = Not available.

Table 3.4-8 Chemicals of Potential Concern in the Inhalation and Multiple Pathway Assessments

Chemicals of Potential Concern	Inhalation Assessment[a]	Multiple Pathway Assessment[b][c]
Aliphatic C_2-C_8 group	✓	✓
Aliphatic C_9-C_{16} group	✓	✓
Aliphatic C_{17}-C_{34} group	✓	✓
Aromatic C_9-C_{16} group	✓	✓
Aromatic C_{17}-C_{34} group	✓	✓
Arsenic	✓	✓
Barium	✓	✓
Benzene	✓	x
Beryllium	✓	✓
Cadmium	✓	✓
Carbon disulphide group	✓	x
Carbon monoxide	✓	x
Carcinogenic PAH group 1	✓	✓
Carcinogenic PAH group 2	✓	✓
Carcinogenic PAH group 3	✓	✓
Chromium	✓	✓
Chromium VI	✓	✓
Cobalt	✓	✓
Copper	✓	✓
Ethylbenzene	✓	x
Ethylene	✓	x
Formaldehyde	✓	x
Hexane group	✓	x
Hydrogen sulphide	✓	x
Lead	✓	✓
Manganese	✓	✓
Mercury	✓	✓
Methyl ethyl ketone group	✓	x
Methyl mercury	x	✓
Molybdenum	✓	✓
Naphthalene group	✓	✓
Nickel	✓	✓
Nitrogen dioxide	✓	x
$PM_{2.5}$	✓	x
Selenium	✓	✓
Sulphur dioxide	✓	x
Toluene	✓	x
Trimethylbenzenes	✓	x
Vanadium	✓	✓
Xylenes	✓	x
Zinc	✓	✓

[a] Methyl mercury will not be emitted by the Project into air; thus, it was not included in the inhalation assessment.

[b] In addition to PAHs and metals, some non-gaseous COPCs that will be emitted directly to air were included in the multiple pathways assessment due to the potential for exposure via secondary pathways based on their ability to persist or accumulate in the environment.

[c] Some non-gaseous COPCs that will be emitted directly into the air were included in the multiple pathway assessment due to the potential for exposure via secondary pathways based on their ability to persist or accumulate in the environment.

✓ COPC was included in the assessment.

x COPC was not included in the assessment.

Inhalation Exposure Assessment

Inhalation exposure estimates were based on the results of air dispersion modelling described in the Air Quality Assessment (Section 1). Predicted air concentrations were presented for various averaging periods (i.e., 10-minute, 1-hour, 8-hour, 24-hour and annual) which were used in the acute and chronic assessments. Predicted ground-level air concentrations for the chemical groups were based on the addition of the air concentrations predicted for each of the COPCs included in the chemical group. For example, the ground-level air concentrations predicted for all 102 of the chemicals in the aliphatic C_2-C_8 group were summed to derive a total air concentration for the aliphatic C_2-C_8 group.

Predicted ground-level air concentrations incorporated emissions associated with all major regional sources as well as background community concentrations (Section 1). As the Air Quality Assessment characterized existing conditions using monitoring data from the Cold Lake South continuous monitoring station, background concentrations were not added to the predicted concentrations.

Multiple Pathway Exposure Assessment

The COPCs that were determined to have the potential to persist or accumulate in the environment were evaluated within a multiple pathway exposure model. The determination of potential exposure to COPCs through multiple pathways relied on both ambient measurements and predictive exposure modelling.

Ambient Measurements

Application of the ambient measurements involves the monitoring of the COPCs in environmental media, preferably in the area of the Project, which is usually accomplished by the simple collection and quantification of the COPCs to provide estimates of ambient levels.

A regional environmental sampling program was conducted in the oil sands development area south of Fort McMurray. The sampling program included five proposed projects:

- Canadian Natural Resources Limited’s (Canadian Natural) Kirby In-Situ Oil Sands Project;
- Canadian Natural’s Primrose East Project;
- ConocoPhillips’ Surmont Commercial SAGD Project;
- EnCana FCCL Oil Sands Ltd. (EnCana) Christina Lake Thermal Project; and

- the Project.

Soil and vegetation (alder, berries, cattail and Labrador tea) were collected between August 2006 and September 2007. A total of 146 soil samples were collected. Alder and berries samples were collected for the two Canadian Natural projects and the ConocoPhillips' project. A total of 46 alder samples and 26 berries samples were collected. Cattail and Labrador tea samples were collected for all of the projects with the exception of EnCana's Christina Lake Thermal Project. A total of 37 cattail samples and 38 Labrador tea samples were collected.

Measured data specific to the Project were used whenever possible to characterize the background exposures to the COPCs from environmental media. Concentrations of the COPCs were measured in air, soil, vegetation, surface water and sediment.

Soil and Vegetation Sampling Program

Consistent with the AENV TOR (AENV 2008), the baseline sampling program focused on those areas traditionally used by people within the Project area as well as the surrounding landscape. Eleven sample locations were identified within the Christina Lake area. At each of these sampling locations, three plant species and corresponding soil samples were collected. Vegetation species were collected to represent leaf vegetables and root vegetables known to be used by humans: Labrador tea and cattail rhizomes. The third species of vegetation was collected to represent forage vegetation (i.e., alder) consumed by wild game. In total, eleven samples of Labrador tea and alder, nine samples of cattail rhizomes and eleven samples of soil were analyzed for a suite of PAHs and metals.

Surface Water Sampling Program

Surface water was collected within the LSA from:

- Waterbodies 1-07, 2-07, 3-07, 4-07, 6-04, 7-04, 12-04;
- Watercourses 1-04, 1-07, 2-07, 3-07, 4-07, 6-04, 6-07, 10-04;
- Christina Lake;
- Winefred Lake; and
- Winefred River.

In total, 52 surface water samples were collected for metal analysis.

Sediment Sampling Program

Sediment was collected within the LSA from:

- Waterbodies 1-07, 2-07, 3-07, 4-07, 6-04, 7-04, 12-04;
- Watercourses 1-04, 1-07, 2-07, 3-07, 4-07, 6-04, 6-07, 10-04;
- Christina Lake;
- Winefred Lake; and
- Winefred River.

In total, 17 sediment samples were collected for metal analysis.

Sampling Program Summary

The measured concentrations were used to characterize background or ambient exposures for the residents in the multiple pathway assessment (Table 3.4-9). For the environmental concentrations of the COPCs that were used in the HHRA, Appendix 3-VIII (Multiple Pathway Exposure Model and Predicted Exposure Point Concentrations).

Soil and vegetation sampling programs have been conducted, in accordance with other oil sands EIAs. Please refer to Appendix 3-IX (Regional Environmental Sampling Data) for a comparison of the Project-specific environmental concentrations used in the HHRA and the regional environmental concentrations.

Table 3.4-9 Measured Background Concentrations of the Chemicals of Potential Concern in the Environmental Media

Environmental Media	Description
Air	Predicted ground-level air concentrations for the EAC incorporated emissions associated with all existing and approved developments, as well as background community sources (Volume 3, Section 1). Because the Air Quality Assessment characterized existing ambient conditions using monitoring data from the Cold Lake South continuous monitoring station, additional background ambient air concentrations were not required.
Soil	Soil concentrations were measured in the Project area. The 95th upper confidence interval on the mean (95 UCLM) was used to characterize background soil concentrations of the COPCs in the region. For those COPCs that were not detected above their MDL or where inconsistent with regional sampling data, the 95 UCLM of measured soil concentrations from EnCana's Christina Lake Thermal Project were used.
Vegetation	Concentrations of the COPCs were measured in edible vegetation from the Project area. The 95 UCLM was used to characterize background concentrations in natural foods (i.e., Labrador tea, blueberry and cattail root), country foods (i.e., fruits and vegetables) and browse for consumption by wild game.

Table 3.4-9 Measured Background Concentrations of the Chemicals of Potential Concern in the Environmental Media (continued)

Environmental Media	Description
Water	Surface water concentrations were measured in Christina Lake, Winefred Lake, Winefred River and a number of unnamed waterbodies and watercourses within the LSA. The 95 UCLM was used to characterize background concentrations of the COPCs in drinking water for Aboriginal residents. The 95 UCLM of the COPC concentrations measured in the municipal water supply from the Conklin water treatment plant were used to characterize background COPC concentrations in drinking water for the community residents (RMWB 2008).
Sediment	Sediment concentrations were measured in Christina Lake, Winefred Lake, Winefred River and a number of unnamed waterbodies and watercourses within the LSA. The 95 UCLM was used to characterize background concentrations of the COPCs in sediment.

Predictive Exposure Modelling

The second approach involved using predictive models to estimate the concentrations of the COPCs in media that lack measured concentrations (i.e., data gaps) or to predict future concentrations (i.e., incremental changes). The models rely on the use of mathematical equations (algorithms) that define the movement of the COPCs from the point of release of the chemicals into the environment (i.e., from the Project) to the point of contact with humans (Health Canada 1995; U.S. EPA 2002). The following data were required for the exposure model:

- concentration of the chemical in environmental media (e.g., air);
- physical–chemical properties of the chemical (e.g., vapour pressure, solubility);
- the chemical's behaviour in the environment (e.g., uptake and distribution);
- local environmental conditions (e.g., soil characteristics, meteorology);
- source characteristics (e.g., operational life of the Project); and
- physiological characteristics (e.g., body weight, breathing rate).

The COPC concentrations were predicted for the EAC (when measured data were not available), Project Case and PDC in air, soil, vegetation, surface water, sediment, fish and wild game. The general approach to predicting COPC concentrations in environmental media is summarized in Table 3.4-10. Please refer to Appendix 3-VIII (Multiple Pathway Exposure Model and Predicted Exposure Point Concentrations) for information regarding the predictive models used in the HHRA.

Table 3.4-10 Predicted Concentrations of the Chemicals of Potential Concern in the Environmental Media

Environmental Media	Description
Air	Air dispersion modelling incorporated meteorological data that represented conditions contributing to maximum predicted ground-level air concentrations of the COPCs. The maximum annual average air concentrations were predicted for each of the identified locations at which people are known or anticipated to spend time on a long-term basis. Air concentrations, including background community sources, were predicted for the EAC, Project Case and PDC (Volume 3, Section 1).
Soil	Soil concentrations used in the multiple pathway assessment were predicted for each lifestyle category (i.e., Aboriginal residents and community residents) under the EAC (when measured data was not available), Project Case and PDC using the highest annual average air concentrations of the locations within each lifestyle category.
Vegetation	Vegetation concentrations used in the multiple pathway assessment were predicted for the EAC (when measured data was not available), Project Case and PDC using: • site-specific Bioconcentration Factors (BCFs) calculated for Labrador tea, cattail roots and alder based on the COPC concentrations measured in soil, or in the case of cattail roots, sediment and vegetation from the region (Appendix 3-VIII); and • the highest annual average air concentrations predicted for each lifestyle category (i.e., Aboriginal residents and community residents).
Water	Because the Water Quality Assessment (Volume 4, Section 5) concluded that the Project would have a negligible effect on surface water quality, it was assumed that concentrations of the COPCs within the local surface waterbodies would remain unchanged from the background concentrations measured within the LSA (Table 3.4-9). Similarly, it was assumed that municipal water quality would not change from the measured background concentrations in the assessment cases. Thus, there was no change in the concentration of the COPCs in drinking water for the Aboriginal and community residents. For those COPCs that were not detected above their MDL in the surface water sampling program or the municipal water supply analysis, background water concentrations were assumed to be negligible (i.e., 0).
Sediment	Sediment concentrations used in the multiple pathway assessment were predicted for each lifestyle category (i.e., Aboriginal residents and community residents) under the EAC (when measured data were not available), Project Case and PDC using the highest annual average air concentrations of the locations within each lifestyle category.
Fish	Concentrations of the COPCs used in the multiple pathway exposure assessment for fish were based on predicted concentrations. Concentrations of the COPCs were estimated in fish based on the surface water concentrations discussed above and literature-derived BCFs.
Wild game	Concentrations of the COPCs used in the multiple pathway exposure assessment for wild game (i.e., large game, small game and game birds) were based on predicted concentrations. Concentrations of the COPCs were estimated in wild game based on the air, soil, vegetation (i.e., alder) and surface water concentrations discussed above.

To compensate for some of the uncertainty associated with the use of modelled predictions, “reasonable worst-case” assumptions were applied to describe the movement of the COPCs to ensure that the predictions do not underestimate potential exposure.

3.4.4.3 Toxicity Assessment

The toxicity assessment involves identifying and understanding potential health effects that can result from exposure to each COPC and the conditions under which the effects might be observed. The toxicity assessment relied on the following guiding principles that have been proven through years of scientific investigation and observation:

- All chemicals, regardless of type or source, possess some degree of intrinsic toxicity (i.e., all chemicals have the capacity to cause some level of harm or injury).
- The health effects produced by any chemical depend on both the intrinsic toxicity of the substance and the exposure, or dose, of the chemical that is received. Potential health effects associated with exposures to the COPCs and the basis of the individual COPC exposure limits, are described in Appendix 3-VII (Toxicity Profiles).
- With few exceptions, the intrinsic toxicity of a chemical (i.e., the capacity to produce a harmful effect or physiological injury) is only expressed if the exposure exceeds a critical threshold level. Below this threshold dose, injury does not occur and health effects are not observed. A possible exception to this principle involves the actions of certain chemical carcinogens that act via genetically mediated mechanisms to produce certain forms of cancer. Some scientists contend that no safe dose levels exist for these carcinogens (Health Canada 2004a). Other scientific authorities disagree and argue that the threshold phenomenon applies equally to carcinogens and non-carcinogens; often this approach to carcinogens is chemical dependant (Health Canada 2006a, Website; Klassen 1996). Debate also surrounds whether or not the threshold phenomenon applies to PM and some other forms of air pollution (Health Canada 2004b; U.S. EPA 2004; WHO 2000, Website). In each case, experimental data demonstrating the absence of a threshold dose are lacking and the exceptions represent theoretical arguments only.
- If the threshold dose is exceeded, health effects can occur. The severity of these effects will depend on the level of exposure received, with more severe effects occurring with increasing dose.
- The toxicity of a chemical depends on its molecular structure. Within limits, chemicals with similar structures will produce similar evidence of toxicity. This principle allows the health effects of a chemical of unknown toxicity to be predicted by comparison with known health effects produced by a second chemical of similar molecular structure.
- The health effects produced by a chemical depend on the nature, extent and duration of exposure. It is important to distinguish between the health effects that might result from acute exposures of short duration

and effects that might occur following chronic or long-term exposure. Also, health effects might differ according to the route of exposure (e.g., inhalation rather than oral exposure).

When evaluating the toxicity of a substance in relation to health, the dose of the substance to which the receptor may be exposed must be considered. It is a fundamental principle of toxicology that the dose determines the type and severity of potential adverse effects that may be associated with exposure. Specifically, it is the amount of the substance that is absorbed and reaches the toxicological site of interest in the organism (in this case, humans) that determines the probability of the adverse effect occurring.

Substances may differ in the mechanisms by which adverse effects are elicited. For example, non-carcinogenic and carcinogenic substances may act via different modes of action. For this reason, two general categories are used to evaluate substances based upon their mode of action or mechanism of toxicity: threshold and non-threshold.

Threshold substances are generally non-carcinogenic and a certain threshold (or maximum dose) must be exceeded before there is a significant risk of adverse effects. For these substances, it is necessary to evaluate the available information to identify exposure levels at which no effects are observed (e.g., a No Observed Effect Level or NOEL), no adverse effects are observed (e.g., a No Observed Adverse Effect Level or NOAEL), or the lowest dose at which an adverse effect has been observed (e.g., a Lowest Observed Adverse Effect Level or LOAEL). In some cases, Benchmark Doses (BMD) are derived and represent a dose level associated with a specific magnitude of response (i.e., 5 or 10% incidence within the study population). In general, BMDs are analogous to NOAELs. All of these endpoints provide an indication of exposure levels that are associated with either minimal or negligible health effects and are often used in the derivation of exposure limit by both governmental and non-governmental organizations.

Carcinogens are generally assumed to not have a threshold of effects. There are various known modes of actions for carcinogens, such as mutagenicity, cytotoxicity, inhibition of cell death, mitogenesis (uncontrolled cell proliferation) and immune suppression (U.S. EPA 2005). In general, tumourigenicity data from animals or human epidemiological studies are evaluated and examined using mathematical models. From these data sets, Risk Specific Concentrations (RsC), Unit Risk Estimates (URE) or Slope Factors (SF) are identified. If the modelling and data set are appropriate, these carcinogenic effect levels are used in the development of exposure limits.

Regulatory agencies such as Health Canada and the U.S. EPA assume that any level of long-term exposure to carcinogenic chemicals is associated with some “hypothetical cancer risk”. As a result, Health Canada and AENV have specified an incremental (i.e., over and above background) lifetime cancer risk of 1 in 100,000, which these agencies consider acceptable, tolerable or essentially negligible (AENV 2001; Health Canada 2004a). The CCME (2006) acknowledges that the designation of negligible cancer risk is an issue of policy rather than science.

An assumed incremental cancer risk of 1 in 100,000 increases a person’s lifetime cancer risk from 0.40000 (based on the 40% lifetime probability of developing cancer in Canada) to 0.40001 (CCS 2006). Because this assumed “acceptable” cancer risk level was specifically developed to address cancer risks over and above background cancer incidence, a portion of which includes background exposure to environmental pollutants, background exposures were not included in the assessment of potential health risks for non-threshold (i.e., carcinogenic) chemicals (Wilson 2005).

The terminology used to define threshold and non-threshold exposure limits differs according to the source and type of exposure and varies between regulatory jurisdictions. Generic nomenclature has been developed, with the following terms and descriptions commonly used:

- Reference Concentration (RfC): refers to the safe level of an airborne chemical for which the primary avenue of exposure is inhalation. It is expressed as a concentration of the chemical in air (i.e., µg/m^3) and applies only to threshold chemicals.
- Reference Dose (RfD): refers to the safe level or dose of a chemical for which exposure occurs through multiple pathways (i.e., inhalation, ingestion and dermal). It is most commonly expressed in terms of the total intake of the chemical per unit of body weight (i.e., µg/kg bw/d). This term applies only to threshold chemicals.
- Risk-Specific Concentration (RsC): reserved for carcinogens and refers to the level of an air-borne carcinogen for which the primary route of exposure is inhalation that results in a “regulatory acceptable” incremental increase in cancer (typically 1 in 100,000). It is expressed as a concentration of the chemical in air (i.e., µg/m^3).
- Risk-Specific Dose (RsD): reserved for carcinogens and refers to the dose of a carcinogen for which exposure occurs through multiple pathways that results in a “regulatory acceptable” increased incidence of cancer (typically 1 in 100,000). It is expressed in terms of the total intake of the chemical (i.e., µg/kg bw/d).

The assessment of the potential toxicity of the COPCs requires an understanding of their respective critical toxicological endpoints of concern. In general, this information is obtained from published scientific studies in humans or animals where the relationship between exposure and toxicity has been examined.

The derivation of exposure limits involves the application of uncertainty or "safety" factors and represent values that are applied to account for inter-species differences (i.e., extrapolation of animal data to humans), intra-species differences (variation within a population where some individuals are more sensitive than others), the extrapolation of subchronic data to a chronic exposure, or limitations in the scientific database.

The effects of a chemical may vary between acute (short-term) and chronic (long-term) exposure. Thus, acute and chronic health assessments are conducted using different sets of exposure limits. Limits for these exposure durations as applied in this HHRA are defined as follows:

- Acute Exposure Limit: The dose of a chemical that may be tolerated without adverse effects on a short-term basis. Acute limits are generally applied to exposures ranging from a few hours to 24 hours.
- Chronic Exposure Limit: The dose of a chemical that may be tolerated without adverse health effects even with continuous or repeated exposures over extended periods, possibly extending over a lifetime.

Selection of Exposure Limits

The criteria used to determine exposure limits may differ in relation to the organization that derived the value. The limits may also vary with respect to the critical toxicological effect upon which the limit is based (e.g., health effects versus nuisance effects such as odour) and the level of protection incorporated into the limit through the use of uncertainty factors.

Exposure limits derived and published by government and non-governmental organizations for the protection of human health were evaluated for each COPC on both an acute and chronic basis. For inclusion in the HHRA, exposure limits were required to be:

- protective of the health of the general public based on current scientific knowledge of the health effects associated with exposure to the COPC;
- protective of sensitive individuals (i.e., children, the immuno-compromised and the elderly) through the incorporation of uncertainty or safety factors;

- established or recommended by reputable scientific or regulatory authorities; and
- supported by adequate documentation.

When these criteria were satisfied by more than one objective, guideline or standard, the most stringent exposure limit was typically selected. In the few cases where the most stringent exposure limit was not selected, the scientific rationale for selection of an alternate limit was provided in Appendix 3-VII (Toxicity Profiles).

Acute Exposure Limits

Inhalation was deemed to be the only relevant pathway of exposure on an acute basis; therefore, only acute inhalation exposure limits were required.

The organizations that were surveyed for acute exposure limits in the HHRA included:

- Alberta Environment's (AENV 2007, Website) Alberta Ambient Air Quality Objectives (AAAOQs);
- Agency for Toxic Substances and Disease Registry's (ATSDR 2006) acute Minimum Risk Levels (MRLs) for hazardous substances;
- California's Office of Environmental Health Hazard Assessment (OEHHA 2007a, Website) acute Reference Exposure Levels (RELs);
- Ontario Ministry of the Environment's (OMOE 2005) summary of O. REG. 419/05 Standards and Point of Impingement Guidelines and Ambient Air Quality Criteria (AAQC); and
- World Health Organization's (WHO 2000, Website) air quality guidelines for Europe (Second Edition).

In instances where an acute inhalation exposure limit that met the four criteria was not obtained from the above agencies, the search was expanded to include:

- ATSDR's (2006) intermediate MRLs for hazardous substances; and
- American Conference of Governmental Industrial Hygienists' (ACGIH 2006) short-term occupational Threshold Limit Values (TLV ceilings) or Short-Term Exposure Limits (STELs).

Oral exposure limits, even if obtained from a short-term study, were not used in the derivation of any acute inhalation limits because:

- the target tissues of the critical effects associated with acute inhalation are often at the portal of entry (i.e., respiratory system);
- differences in absorption between the respiratory system and the digestive system; and
- oral exposure limits can be based on repeated dosing via the oral route of exposure (i.e., gavage [force feeding through a tube], ingestion).

Chronic Exposure Limits

Exposure limits for the chronic effects assessment were used to present the potential health risks associated with long-term inhalation and multiple pathways exposure to COPCs.

For the multiple pathway assessment, exposure limits for all pathways of exposure were used, where available. Refer to Appendix 3-VII (Toxicity Profiles) for details on the selection of chronic exposure limits.

The sources of the chronic exposure limits used in this HHRA included:

- ATSDR's (2006) chronic Minimum Risk Levels (MRLs) for hazardous substances;
- Canadian Council of Ministers of the Environment's (CCME 2000b) CWS for Petroleum Hydrocarbons;
- Health Canada's (2004a) Toxicological Reference Values (TRVs);
- Netherlands National Institute of Public Health and the Environment's (RIVM 2001) Maximum Permissible Risk Levels (MPRLs);
- U.S. Environmental Protection Agency's (U.S. EPA 2007, Website) Integrated Risk Information System (IRIS) Database; and
- WHO's (2000, Website) air quality guidelines for Europe (Second Edition).

Once again, if a suitable exposure limit was not available from one of these regulatory agencies, the search was expanded to include:

- chronic RELs developed by the OEHHA (2007b, Website); and
- TLVs developed by the ACGIH (2006).

Summary of Exposure Limits

A complete list of the acute and chronic exposure limits used in the HHRA is presented in Table 3.4-11.

Table 3.4-11 Exposure Limits for Chemicals of Potential Concern

COPC	Acute Inhalation Exposure Limit		Chronic Inhalation Exposure Limit		Chronic Oral Exposure Limit	
	Averaging Time	Value [µg/m^3]	Type	Value [µg/m^3]	Type	Value [µg/kg bw/d]
Aliphatic C_2-C_8 group	1-hour	100,000	RfC	18,400	RfD	5,000
Aliphatic C_9-C_{16} group	1-hour	2,600	RfC	200	RfD	100
Aliphatic C_{17}-C_{34} group	–	–	RfC	8,950	RfD	2,000
Aromatic C_9-C_{16} group	1-hour	9,000	RfC	200	RfD	40
Aromatic C_{17}-C_{34} group	–	–	RfC	130	RfD	30
Arsenic	1-hour	0.19	RsC	0.0016	RsD	0.006
Barium	–	–	RfC	63	RfD	200
Benzene	24-hour	30	RsC	1.3	n/a	n/a
Beryllium	1-hour	0.25	RsC	0.004	RfD	2
Cadmium	–	–	RsC	0.006	RfD	1
Carbon disulphide group	1-hour	6,200	RfC	100	n/a	n/a
Carbon monoxide	1-hour 8-hour	15,000 6,000	–	–	n/a	n/a
Carcinogenic PAH group 1	–	–	RsC	0.32	RsD	0.0014
Carcinogenic PAH group 2	–	–	RsC	3.2	RsD	0.014
Carcinogenic PAH group 3	–	–	RsC	10.7	RsD	0.047
Chromium	–	–	RfC	60	RfD	1,500
Chromium VI	24-hour	1	RsC	0.00013	RfD	3
Cobalt	–	–	RfC	0.1	–	–
Copper	1-hour	100	RfC	1	RfD	140
Ethylbenzene	24-hour	4,340	RfC	1,000	n/a	n/a
Ethylene	–	–	RfC	8,200	n/a	n/a
Formaldehyde	2-hour	50	RsC	0.8	n/a	n/a
Hexane group	1-hour	4,300	RfC	700	n/a	n/a
Hydrogen sulphide	1-hour	98	RfC	2	n/a	n/a
Lead	24-hour	0.8	RfC	0.5	RfD	3.5
Manganese	–	–	RfC	0.04	RfD	140
Mercury	1-hour	1.8	RfC	0.3	RfD	0.3
Methyl ethyl ketone group	1-hour	13,000	RfC	5,000	n/a	n/a
Methyl mercury	n/a	n/a	n/a	n/a	RfD	0.1
Molybdenum	–	–	RfC	12	RfD	5
Naphthalene group	1-hour	2,000	RfC	3	RfD	20
Nickel	1-hour	6	RsC	0.0077	RfD	22
Nitrogen dioxide	1-hour 24-hour	400 200	RfC	60	n/a	n/a
$PM_{2.5}$	24-hour	30	RfC	12	n/a	n/a
Selenium	–	–	RfC	0.7	RfD	5

Table 3.4-11 Exposure Limits for Chemicals of Potential Concern (continued)

COPC	Acute Inhalation Exposure Limit		Chronic Inhalation Exposure Limit		Chronic Oral Exposure Limit	
	Averaging Time	Value [µg/m^3]	Type	Value [µg/m^3]	Type	Value [µg/kg bw/d]
Sulphur dioxide	10-minute	500	RfC	30	n/a	n/a
	1-hour	450				
	24-hour	150				
Toluene	1-hour	37,000	RfC	5,000	n/a	n/a
Trimethylbenzenes	1-hour	5,000	RfC	4,400	n/a	n/a
Vanadium	24-hour	0.2	RfC	0.07	RfD	5
Xylenes	2-hour	8,700	RfC	100	n/a	n/a
Zinc	–	–	RfC	70	RfD	300

n/a = Not applicable; chronic oral exposure limits were only required for those COPCs that will persist or accumulate in the environment and were thus included in the multiple pathway assessment. Methyl mercury will not be emitted into the air by the Project and thus was assessed in the multiple pathway assessment only.

– = Not available.

Chemical Mixtures

Given that chemical exposures rarely occur in isolation, the potential health effects associated with mixtures of the COPCs were assessed in the HHRA. Although the interaction between chemicals can take many forms, additive interactions were assumed for the HHRA (Health Canada 2004a). Additive interactions apply most readily to chemicals that are structurally similar, act toxicologically through similar mechanisms or affect the same target tissue in the body (i.e., share commonality in effect) (Health Canada 2004a).

Potential additive interactions were identified for specific COPCs that may cause:

- irritation of the eyes, nose or respiratory tract;
- liver toxicity;
- kidney toxicity;
- haematological (i.e., blood) toxicants;
- immunological toxicity;
- neurotoxicity;
- developmental and reproductive toxicity; or
- cancer of the nasal cavity, lung, liver, stomach or blood (i.e., leukemia).

An individual chemical's inclusion in a chemical mixture was determined based on the endpoints of the exposure limits used in the HHRA. For example, the acute inhalation exposure limit for acetaldehyde is based on its ability to cause eye and respiratory tract irritation, thus acetaldehyde was included in both the acute inhalation “eye irritant” and “respiratory tract irritant” mixture.

In the case of acrolein, the critical endpoint for the acute inhalation exposure limit is based on eye irritation only, meaning that acrolein was included in the acute inhalation “eye irritant” mixture. However, given recent concerns expressed by provincial regulators over the possible respiratory irritant properties of acrolein, the potential additive interactions of acrolein were expanded to include both nasal and respiratory irritation. To accurately reflect the potential risk associated with these additional endpoints, a second acute inhalation exposure limit based on irritation of the nose and throat was obtained from the previously identified scientific and regulatory agencies. For details concerning the critical endpoints of the chemicals included in each of the mixtures, see Appendix 3-VII (Toxicity Profiles).

The chemical constituents of the mixtures are listed in Table 3.4-12.

Table 3.4-12 Potential Additive Interactions of the Chemicals of Potential Concern

Exposure Characteristics	Potential Health Effect of Mixture	Toxicant Designation	Chemicals of Potential Concern
acute inhalation exposure	irritation	eye irritants	formaldehyde, methyl ethyl ketone group, naphthalene group
		nasal irritants	beryllium, formaldehyde, methyl ethyl ketone group
		respiratory tract irritants	beryllium, chromium VI, copper, hydrogen sulphide, methyl ethyl ketone group, nickel, NO_2, SO_2, vanadium, xylenes
	liver and kidney effects	hepato- and renal toxicants	aliphatic C_2-C_8 group, aromatic C_9-C_{16} group
	immunological effects	immunotoxicants	benzene, nickel
	neurological effects	neurotoxicants	aliphatic C_9-C_{16} group, aromatic C_9-C_{16} group, carbon disulphide group, hexane group, lead, toluene, trimethylbenzenes, xylenes
	reproductive/ developmental effects	reproductive/ developmental toxicants	arsenic, carbon disulphide group, ethylbenzene, lead, mercury
chronic inhalation exposure	irritation	nasal irritants	hydrogen sulphide, naphthalene group
		respiratory tract irritants	cobalt, copper, NO_2, selenium, SO_2, trimethylbenzenes, vanadium, zinc
	liver effects	hepatotoxicants	aliphatic C_{17}-C_{34} group, aromatic C_9-C_{16} group
	kidney effects	renal toxicants	aromatic C_9-C_{16} group, aromatic C_{17}-C_{34} group, barium
	neurological effects	neurotoxicants	aliphatic C_2-C_8 group, aliphatic C_9-C_{16} group, aromatic C_9-C_{16} group, carbon disulphide group, hexane group, lead, manganese, mercury, toluene, trimethylbenzenes, xylenes
	reproductive/ developmental effects	reproductive/ developmental toxicants	ethylbenzene, lead, methyl ethyl ketone group
	cancer	lung carcinogens	arsenic, beryllium, cadmium, carcinogenic PAH groups 1-3, chromium VI, nickel

Table 3.4-12 Potential Additive Interactions of the Chemicals of Potential Concern (continued)

Exposure Characteristics	Potential Health Effect of Mixture	Toxicant Designation	Chemicals of Potential Concern
chronic oral exposure	liver effects	hepatotoxicants	aliphatic C_9-C_{16} group, aliphatic C_{17}-C_{34} group, aromatic C_9-C_{16} group
	kidney effects	renal toxicants	aromatic C_9-C_{16} group, aromatic C_{17}-C_{34} group, barium, cadmium
	haematological effects	haematological toxicants	aliphatic C_9-C_{16} group, zinc
	neurological effects	neurotoxicants	aliphatic C_2-C_8 group, lead, manganese, methyl mercury
	reproductive/ developmental effects	reproductive/ developmental toxicants	lead, methyl mercury, nickel
	cancer	stomach carcinogens	carcinogenic PAH groups 1-3

Chemical interactions were not assessed for transient persons because the predicted locations along the fence-line where the maximum chemical concentrations would occur differed between the COPCs. For example, the fence-line location where the maximum ground-level air concentration for acetaldehyde was predicted to occur would not necessarily correspond to the location at which the maximum acetone concentration was predicted to occur.

3.4.4.4 Risk Characterization

Risk estimates are presented as potential Project-specific effects and cumulative effects for both acute and chronic exposures. The potential health risks associated with COPC emissions from the Project are expressed as Risk Quotients (RQs) for the non-carcinogenic COPCs and as Incremental Lifetime Cancer Risks (ILCRs), or Lifetime Cancer Risks (LCRs) in the EAC, for the carcinogenic COPCs.

Risk Quotients

Risk Quotients were calculated by comparing the predicted levels of exposure for the non-carcinogenic COPCs with their respective exposure limits developed by regulatory or scientific authorities. The chronic RQs for three of the assessment cases (i.e., EAC, Project and PDC) are calculated as follows:

$$\mathbf{RQ} = \frac{\text{Air Concentration } (\mu g/m^3)}{\text{RfC } (\mu g/m^3)}$$

or

$$\mathbf{RQ} = \frac{\text{Exposure Estimate } (\mu g/kg \text{ bw/d})}{\text{RfD } (\mu g/kg \text{ bw/d})}$$

Interpretation of the RQ values proceeded as follows:

- RQ ≤ 1 signifies that the estimated exposure is less than or equal to the exposure limit (i.e., the assumed safe level of exposure). This shows that negligible health risks are predicted. Added assurance of protection is provided by the high degree of conservatism incorporated in the derivation of the exposure limit and exposure estimate; and
- RQ >1 signifies the exposure estimate exceeds the exposure limit. This suggests an elevated level of risk, the significance of which must be balanced against the high degree of conservatism incorporated in the risk assessment (i.e., the margin of safety is reduced but not removed entirely).

Lifetime Cancer Risks and Incremental Lifetime Cancer Risks

Potential risks associated with the COPCs deemed to be carcinogenic to animals and/or humans (i.e., arsenic, benzene, beryllium, cadmium, carcinogenic PAH group 1, carcinogenic PAH group 2, carcinogenic PAH group 3, chromium VI, formaldehyde and nickel) are expressed as LCRs for the EAC, or ILCRs for the Project (i.e., Project Case minus EAC) and the Future Emission Sources (i.e., PDC minus EAC). The distinction between LCRs and ILCRs lies in their interpretation.

For the EAC, the LCRs simply refer to the number of cancer cases that could potentially result from the estimated exposures to the carcinogenic COPCs in a population of 100,000 people. A policy-based regulatory benchmark of an acceptable incremental lifetime cancer risk of 1 in 100,000 has been developed. However, regulators have not recommended an acceptable cancer incidence rate (or LCR) for exposure to carcinogens associated with background or “baseline” conditions. Thus, interpretation of the significance of the EAC LCR values could not be based on the regulatory “benchmark” of 1 in 100,000.

Lifetime Cancer Risks for the EAC were calculated as follows:

$$\mathbf{LCR} = \frac{\text{Air Concentration } (\mu g/m^3)}{\text{RsC } (\mu g/m^3)}$$

or

$$\mathbf{LCR} = \frac{\text{Exposure Estimate } (\mu g/kg\ bw/d)}{\text{RsD } (\mu g/kg\ bw/d)}$$

For the incremental change attributable to the Project and Future Emission Sources, the ILCRs refer to the predicted additional cancer cases that could potentially result from the incremental exposures to carcinogenic COPCs released by the Project and Future Emission Sources in the region. Interpretation of these ILCRs was based on comparison of ILCR values associated with the Project and Future Emission Sources with the “benchmark” of 1 in 100,000 (i.e., one extra cancer case in a population of 100,000 people). This benchmark corresponds to a *de minimus* risk level considered acceptable by most leading authorities for the protection of public health. The *de minimus* risk level is defined as a level of negligible risk to the individual.

The ILCRs were calculated as follows:

$$\mathbf{ILCR} = \frac{\text{Incremental Air Concentration } (\mu g/m^3)}{\text{RsC } (\mu g/m^3)}$$

or

$$\mathbf{ILCR} = \frac{\text{Incremental Exposure Estimate } (\mu g/kg\ bw/d)}{\text{RsD } (\mu g/kg\ bw/d)}$$

Interpretation of the ILCR values in this instance will proceed as follows:

- ILCR ≤ 1 signifies an incremental lifetime cancer risk that is below the benchmark ILCR of 1 in 100,000 (i.e., within the accepted level of risk set by provincial and federal regulatory agencies); and
- ILCR >1 signifies an incremental lifetime cancer risk that is greater than the benchmark ILCR of 1 in 100,000, the interpretation of which must consider the conservatism incorporated in the assessment.

Conservative Assumptions

A high degree of conservatism was incorporated into the HHRA to ensure that health risks would not be overlooked or understated. A summary of the conservative assumptions that were incorporated into the HHRA can be found in Table 3.4-13, arranged according to the steps of the risk assessment paradigm (Figure 3.4-2). Examination of the table shows that conservatism was introduced at virtually every step of the assessment and extended to both the exposure and toxicity assessment of the HHRA.

Table 3.4-13 Major Assumptions Used in the Human Health Risk Assessment

Risk Assessment Paradigm	Assumption	Discussion of Conservatism
Exposure Assessment	Air dispersion modelling incorporated meteorological data that represented conditions contributing to maximum predicted ground-level air concentrations of the COPCs.	Use of the maximum predicted ground-level air concentrations of the COPCs likely contributed to the exaggeration of the exposures that might be received by people residing or visiting the area under most circumstances.
	Transient persons might be found anywhere in the area (including the MPOIs), presenting the possibility that they could be exposed to the maximum predicted ground-level air concentrations of the COPCs attributable to the Project.	The choice of these locations is likely to contribute to the exaggeration of the exposures that might be received by the transient persons under most circumstances, as it is unlikely that transient persons will be engaged in traditional or recreational activities at the location along the fence-line of the Project area and at the exact time when the meteorological conditions contributing to the maximum concentrations occur.
	The people with the highest predicted exposures within each lifestyle category (i.e., transient persons, Aboriginal residents and community residents) were used to characterize the potential exposures for all people represented by the lifestyle category.	Potential exposure assumed for each lifestyle category represents a “reasonable worst-case” scenario. This contributes to the exaggeration of the potential risks other people in the lifestyle category may be presented with. (Note that the potential health risks for all of the discrete locations are provided in Appendix 3-X).

Table 3.4-13 Major Assumptions Used in the Human Health Risk Assessment (continued)

Risk Assessment Paradigm	Assumption	Discussion of Conservatism
Exposure Assessment (cont'd)	Predicted chronic exposures for the permanent residents were based on the assumption that individuals would be exposed 24 hours per day for 365 days per year to the maximum predicted ground-level air concentrations of the COPCs for the entire duration of their lives (i.e., 75 years).	The operating "life" of the Project is expected to be 34 years; thus, assuming 75 years of COPC emissions into the air as well as 75 years of deposition is likely to contribute to the exaggeration of actual levels of exposures. Furthermore, Aboriginal residents would not be expected to maintain year-round occupancy at the cabins.
	Predicted chronic multiple pathway exposures were estimated for all life stages, but only the results of the most sensitive age groups were reported.	Predicted exposures for the other life stages are anticipated to be lower than those reported.
	Aboriginal residents were assumed to obtain all (100%) of their food from local natural food sources (e.g., wild game, fish, berries, cattail roots and plants) and drinking water from local surface waterbodies.	The assumption that the Aboriginal residents obtain all of their food over their lifetime from the area is likely to contribute to the exaggeration of the exposures that might be received by these people under actual circumstances.
	Community residents were assumed to obtain all (100%) of their food from local natural food sources (e.g., wild game, fish and plants) and drinking water from municipal water supply. In addition, community residents were assumed to obtain 10% of their local country food sources (i.e., fruits and vegetables) from local sources. It was assumed that 90% of local country food sources would be purchased at the supermarket (CCME 2006).	The assumption that community residents obtain all of their natural food sources and 10% of their country food sources over their lifetime from the local area likely exaggerates the actual levels of exposure.
	Predicted environmental media concentrations (i.e., soil, plant, wild game, water and fish) were based on 75 years of continuous Project emissions and associated chemical deposition, to represent an individual's assumed lifespan.	The operating "life" of the Project is expected to be 34 years; thus, assuming 75 years of COPC emissions into the air as well as 75 years of deposition is likely to contribute to the exaggeration of the exposures by both primary and secondary pathways.
	Tissue concentrations from local wild game, such as moose, snowshoe hare and ruffed grouse, were based on the maximum predicted ground-level air concentrations of the fence-line MPOI locations and all discrete receptor locations.	Apart from the fact that it is unlikely that wild game will forage at one discrete location over their entire lifetime, assuming that wild game will forage at the location where the maximum concentrations are predicted in air, soil, water and vegetation over their lifetime is likely to contribute to the exaggeration of the exposures to people that consume wild game.
	No degradation of the persistent or accumulative COPCs would occur over time (i.e., only continuous accumulation).	Degradation of many of the persistent or accumulative COPCs will occur over time. Assuming no degradation overestimates potential exposure.
Toxicity Assessment	Exposure limits were developed to be protective of the sensitive and more susceptible individuals within the general population (e.g., infants and young children, the elderly, individuals with compromised health) (ATSDR 2006; U.S. EPA 2007, Website).	A considerable amount of conservatism is incorporated in the exposure limits. Limits are deliberately set to be protective of sensitive individuals. The limits were derived from the most sensitive endpoints and then adjusted to account for differences in sensitivity to chemicals among individuals. The use of uncertainty factors is directed, in part, toward the protection of sensitive individuals.

Table 3.4-13 Major Assumptions Used in the Human Health Risk Assessment (continued)

Risk Assessment Paradigm	Assumption	Discussion of Conservatism
Toxicity Assessment (cont'd)	The findings from toxicity studies with laboratory rodents can be used to gauge the types of responses and health effects that the chemicals may cause in humans and the findings from the laboratory rodent studies can be used, in part, to determine exposure limits for the chemicals.	Laboratory rodents have traditionally served as suitable surrogate species for humans. The use of uncertainty factors accounts for the possible differences in responses to chemicals that might be observed between laboratory rodents and other species, such as humans (see Appendix 3-VII). However, recent evidence suggests that rodents might be more sensitive to nasal effects than humans as a result of higher doses reaching the critical target site in rodents.
	The exposure limits for any surrogate chemicals adequately represent the toxicity of the chemicals being represented.	In the absence of toxicity data for a number of the individual chemicals in the initial inventory, it was necessary to assume that structural similarity to the surrogates was a sufficient basis for the assumption of toxicological similarity.
	Possible interactions of the COPCs released by the Project, which might lead to enhanced toxicity, were adequately addressed in the assessment.	Additive interactions were included as part of the assessment after consideration of chemical structure, target tissue(s) and mechanism of toxic action (Health Canada 2004a).

3.5 MITIGATION

Considering the results of the HHRA, no mitigation measures are recommended in addition to those planned in support of the Air Quality (Sections 1.4 and 1.10) and Aquatic Resources Assessments (Volume 4, Sections 3 and 7).

Most relevant to the HHRA are those mitigation measures intended to minimize the potential changes to air quality. With respect to air quality, the Project will comply with the following provincial and federal emissions guidelines in the design of the process and selection of equipment:

- the new steam generators and heater at the Project will be in compliance with the CCME *National Emission Guidelines for Commercial/Industrial Boilers and Heaters*, where applicable;
- when produced gas and natural gas are used to fire steam generators, the (EUB 2001) ERCB sulphur recovery guidelines as per EUB ID 2001-3 will be met;
- flaring will be minimized for the Project (e.g., upset/emergency conditions, start-up and commissioning); and

- above-ground storage tanks will conform to environmental guidelines for controlling emissions of volatile organic compounds from above-ground storage tanks.

3.6 EXISTING AND APPROVED CASE, PROJECT CASE AND PLANNED DEVELOPMENT CASE ASSESSMENT

Given that health effects are dependent, in part, on the duration of exposure, separate assessments were completed for the acute and chronic exposure estimates. It is important to distinguish between potential health effects that might result from acute exposure or chronic exposure. For example, short-term exposure of formaldehyde in air is associated with eye and nasal irritation while long-term inhalation can produce carcinogenic nasal lesions.

In the chronic assessment, further distinction was made between inhalation and multiple pathway exposures since the pathway of exposure will also influence the potential health effects associated with each of the COPCs. For example, chronic inhalation of cadmium can produce lung cancer but chronic oral exposure (i.e., ingestion) may result in kidney effects.

In recognition of the influence of duration and pathway of exposure, risk estimates were segregated into:

- acute inhalation;
- chronic inhalation; and
- chronic multiple pathways.

The acute and chronic risk estimates are presented in scientific notation as many of the calculated numerical values are well below 1.0. For instance, the acute risk estimate for the transient persons exposed to the maximum aliphatic C_2-C_8 group air concentration under the EAC is 3.1E-04, which is equivalent to an RQ of 0.00031 (Table 3.6-1). The discussion of the results focuses on risk estimates that exceeded 1.0, as they could signify potential health risks. Where risk estimates did not exceed 1.0 (i.e., where the predicted exposures were less than the exposure limits), the predicted risk values are presented in the tables but were not discussed further.

3.6.1 Acute Inhalation Assessment

This section addresses key question HHPDC-1, which asked “What are the risks of adverse human health effects from short-term (acute) exposure to air emissions from existing and approved developments, the Project and planned developments?"

Acute inhalation risk estimates, expressed as RQs, were based on assumed exposure periods that range from a few minutes (e.g., 10-minute SO_2) to 24 hours (e.g., $PM_{2.5}$). The maximum acute RQ values for the transient persons, Aboriginal residents and community residents are presented in Table 3.6-1 through Table 3.6-3. Inhalation risk quotients for all "receptor" locations are presented in Appendix 3-X.

With one exception, predicted acute RQ values did not exceed 1.0 for any of the individual COPCs and chemical mixtures under any of the three assessment cases (i.e., EAC, Project Case and PDC). This demonstrates that in almost all cases, predicted COPC air concentrations were less than their health-based guidelines and the additive interactions of the COPCs are not predicted to result in health-related impacts. Therefore, health risks for these COPCs and mixtures are considered negligible.

The one exception pertained to SO_2 based on a 10-minute averaging time for the transient persons, only. The following section provides more detail on the potential health risks associated with short-term exposure to SO_2.

Table 3.6-1 Acute Inhalation Risk Quotients – Transient Persons

Chemicals Of Potential Concern[(a)(b)]	Averaging Time	Risk Quotients[(c)]		
		Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1-hour	3.1E-04	4.9E-04	5.3E-04
Aliphatic C_9-C_{16} group	1-hour	3.2E-03	4.1E-03	4.5E-03
Aromatic C_9-C_{16} group	1-hour	1.6E-04	1.6E-04	2.0E-04
Arsenic	1-hour	2.0E-03	5.7E-03	5.7E-03
Benzene	24-hour	2.2E-03	2.3E-03	2.9E-03
Beryllium	1-hour	9.4E-05	2.6E-04	2.6E-04
Carbon disulphide group	1-hour	7.9E-05	1.1E-04	1.1E-04
Carbon monoxide	1-hour	1.2E-02	3.1E-02	3.1E-02
	8-hour	2.2E-02	6.2E-02	6.2E-02
Chromium VI	24-hour	1.2E-04	2.3E-04	2.4E-04
Copper	1-hour	1.7E-05	4.6E-05	4.6E-05
Ethylbenzene	24-hour	1.3E-04	1.3E-04	1.5E-04
Formaldehyde	1-hour	1.4E-02	1.5E-02	1.5E-02
Hexane group	1-hour	1.5E-03	1.9E-03	2.2E-03
Hydrogen sulphide	1-hour	5.3E-02	7.6E-02	7.6E-02
Lead	24-hour	5.2E-04	1.0E-03	1.0E-03
Mercury	1-hour	2.8E-04	7.8E-04	7.8E-04
Methyl ethyl ketone group	1-hour	2.9E-05	4.1E-05	4.1E-05
Naphthalene group	1-hour	7.4E-05	7.5E-05	7.5E-05

Table 3.6-1 Acute Inhalation Risk Quotients – Transient Persons (continued)

Chemicals Of Potential Concern[a][b]	Averaging Time	Risk Quotients[c]		
		Existing and Approved Case	Project Case	Planned Development Case
Nickel	1-hour	7.2E-04	1.9E-03	1.9E-03
Nitrogen dioxide	1-hour	2.1E-01	3.9E-01	3.9E-01
	24-hour	2.1E-01	2.2E-01	2.2E-01
$PM_{2.5}$[d]	24-hour	2.0E-01	3.3E-01	3.6E-01
Sulphur dioxide	10-minute	8.1E-01	**1.2E+00**	**1.2E+00**
	1-hour	6.3E-01	9.2E-01	9.3E-01
	24-hour	4.4E-01	7.9E-01	8.0E-01
Toluene	1-hour	4.8E-05	4.8E-05	6.8E-05
Trimethylbenzenes	1-hour	5.0E-05	5.0E-05	6.9E-05
Vanadium	24-hour	1.4E-02	2.0E-02	2.0E-02
Xylenes	1-hour	2.5E-04	2.5E-04	3.2E-04

[a] Aliphatic C_{17}-C_{34} group, aromatic C_{17}-C_{34} group, barium, cadmium, carcinogenic PAH groups 1-3, chromium, cobalt, ethylene, manganese, methyl mercury, molybdenum, selenium and zinc were not included in the acute inhalation assessment due to the lack of an adequate acute inhalation exposure limit for the COPCs or, in the case of methyl mercury, it will not be emitted into the air by the Project.

[b] Mixtures were not assessed for transient persons because the fence-line MPOIs are chemical-specific; that is to say, the location along the fence-line at which the maximum ground-level air concentration for benzene was predicted would not necessarily correspond to the location at which the maximum ground-level air concentration for nickel was predicted.

[c] A Risk Quotient equal to or less than 1.0 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. Values in bold show an RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[d] Health Canada's SUM15 method, which is different from more recent methods and calculates excess health risk when $PM_{2.5}$ air concentrations exceed a daily threshold of 15 µg/m^3 (Health Canada 1999) is provided in Appendix E (Health Canada's SUM15 Assessment of $PM_{2.5}$ Health Risks).

Table 3.6-2 Acute Inhalation Risk Quotients – Aboriginal Residents

Chemicals of Potential Concern[a]	Averaging Time	Risk Quotients[b]		
		Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1-hour	4.0E-04	4.0E-04	5.1E-04
Aliphatic C_9-C_{16} group	1-hour	3.9E-03	3.9E-03	5.0E-03
Aromatic C_9-C_{16} group	1-hour	2.1E-04	2.1E-04	2.6E-04
Arsenic	1-hour	4.0E-04	6.3E-04	6.6E-04
Benzene	24-hour	3.6E-03	3.6E-03	4.0E-03
Beryllium	1-hour	2.1E-05	2.9E-05	3.2E-05
Carbon disulphide group	1-hour	8.1E-06	8.1E-06	9.6E-06
Carbon monoxide	1-hour	2.6E-02	2.6E-02	2.7E-02
	8-hour	4.3E-02	4.3E-02	4.4E-02
Chromium VI	24-hour	7.3E-05	7.3E-05	8.1E-05
Copper	1-hour	3.3E-06	5.0E-06	5.4E-06
Ethylbenzene	24-hour	1.9E-04	1.9E-04	2.1E-04
Formaldehyde	1-hour	1.1E-02	1.1E-02	1.1E-02
Hexane group	1-hour	2.1E-03	2.1E-03	2.6E-03
Hydrogen sulphide	1-hour	2.3E-03	3.3E-03	3.4E-03
Lead	24-hour	2.0E-04	2.0E-04	2.6E-04

Table 3.6-2 Acute Inhalation Risk Quotients – Aboriginal Residents (continued)

Chemicals of Potential Concern[a]	Averaging Time	Risk Quotients[b]		
		Existing and Approved Case	Project Case	Planned Development Case
Mercury	1-hour	4.1E-05	8.6E-05	9.0E-05
Methyl ethyl ketone group	1-hour	2.3E-05	2.3E-05	2.6E-05
Naphthalene group	1-hour	2.7E-06	2.8E-06	3.9E-06
Nickel	1-hour	5.7E-04	5.7E-04	7.0E-04
Nitrogen dioxide	1-hour	1.4E-01	1.4E-01	1.7E-01
	24-hour	1.2E-01	1.2E-01	1.5E-01
$PM_{2.5}$[d]	24-hour	3.3E-01	3.4E-01	3.7E-01
Sulphur dioxide	10-minute	1.7E-01	1.7E-01	9.1E-02
	1-hour	1.4E-01	1.4E-01	7.1E-02
	24-hour	1.3E-01	1.3E-01	1.2E-01
Toluene	1-hour	7.1E-05	7.1E-05	9.5E-05
Trimethylbenzenes	1-hour	7.2E-05	7.2E-05	9.6E-05
Vanadium	24-hour	1.0E-02	1.1E-02	1.1E-02
Xylenes	1-hour	3.7E-04	3.7E-04	4.6E-04
Mixtures[c]				
Eye irritants	n/a	1.1E-02	1.1E-02	1.1E-02
Nasal irritants	n/a	1.1E-02	1.1E-02	1.1E-02
Respiratory tract irritants	n/a	2.5E-01	2.6E-01	2.9E-01
Hepato- and renal toxicants	n/a	6.2E-04	6.2E-04	7.7E-04
Immunotoxicants	n/a	4.2E-03	4.2E-03	4.7E-03
Neurotoxicants	n/a	6.9E-03	6.9E-03	8.8E-03
Reproductive/ developmental toxicants	n/a	8.3E-04	9.9E-04	1.1E-03

(a) Aliphatic C_{17}-C_{34} group, aromatic C_{17}-C_{34} group, barium, cadmium, carcinogenic PAH groups 1-3, chromium, cobalt, ethylene, manganese, methyl mercury, molybdenum, selenium and zinc were not included in the acute inhalation assessment due to the lack of an adequate acute inhalation exposure limit for the COPCs or, in the case of methyl mercury, it will not be emitted into the air by the Project.

(b) A Risk Quotient equal to or less than 1.0 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. Values in bold show an RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-13. Note that addition of the individual RQ values provided in the above table for a mixture's chemical constituents might not equate to the RQ value provided for the mixture because the RQ values in the table represent the highest RQ for the lifestyle category. For example, in the EAC, the formaldehyde RQ in the above table is based on predictions at Christina Lake Lodge, while the RQ for the naphthalene group is based on Hunter/Trapper A and the RQ for the "eye irritants" mixture is based on Christina Lake Lodge.

(d) Health Canada's SUM15 method, which is different from more recent methods and calculates excess health risk when $PM_{2.5}$ air concentrations exceed a daily threshold of 15 $\mu g/m^3$ (Health Canada 1999) is provided in Appendix 3-XI (Health Canada's SUM15 Assessment of $PM_{2.5}$ Health Risks).

n/a = Not applicable; averaging-times are not specified for the acute mixtures because the RQ values for the chemical mixtures were based on a combination of acute averaging-times (i.e., 10-minute, 1-hour and 24-hour) depending on the individual COPCs included in the mixture.

Table 3.6-3 Acute Inhalation Risk Quotients – Community Residents

Chemicals Of Potential Concern[a]	Averaging Time	Risk Quotients[b]		
		Existing and Approved Case	**Project Case**	**Planned Development Case**
Aliphatic C_2-C_8 group	1-hour	3.7E-04	3.7E-04	4.3E-04
Aliphatic C_9-C_{16} group	1-hour	3.1E-03	3.1E-03	3.5E-03
Aromatic C_9-C_{16} group	1-hour	1.5E-04	1.5E-04	1.8E-04
Arsenic	1-hour	3.6E-04	4.0E-04	4.1E-04
Benzene	24-hour	3.3E-02	3.3E-02	3.3E-02
Beryllium	1-hour	1.7E-05	1.8E-05	2.0E-05
Carbon disulphide group	1-hour	5.7E-06	5.8E-06	6.7E-06
Carbon monoxide	1-hour	1.9E-02	1.9E-02	1.9E-02
	8-hour	2.7E-02	2.8E-02	2.8E-02
Chromium VI	24-hour	5.3E-05	5.6E-05	6.6E-05
Copper	1-hour	2.7E-06	3.0E-06	3.3E-06
Ethylbenzene	24-hour	1.3E-04	1.3E-04	1.4E-04
Formaldehyde	1-hour	3.5E-02	3.5E-02	3.6E-02
Hexane group	1-hour	2.0E-03	2.0E-03	2.4E-03
Hydrogen sulphide	1-hour	4.7E-03	4.7E-03	4.7E-03
Lead	24-hour	1.5E-04	1.6E-04	2.1E-04
Mercury	1-hour	4.4E-05	4.8E-05	4.5E-05
Methyl ethyl ketone group	1-hour	7.3E-05	7.3E-05	7.3E-05
Naphthalene group	1-hour	4.5E-06	4.5E-06	4.6E-06
Nickel	1-hour	3.9E-04	3.9E-04	4.1E-04
Nitrogen dioxide	1-hour	2.1E-01	2.1E-01	2.2E-01
	24-hour	1.6E-01	1.6E-01	1.7E-01
$PM_{2.5}$[d]	24-hour	3.1E-01	3.2E-01	3.6E-01
Sulphur dioxide	10-minute	1.3E-01	1.3E-01	1.0E-01
	1-hour	1.0E-01	1.0E-01	7.8E-02
	24-hour	1.6E-01	1.6E-01	9.1E-02
Toluene	1-hour	5.4E-05	5.4E-05	6.3E-05
Trimethylbenzenes	1-hour	4.9E-05	4.9E-05	6.6E-05
Vanadium	24-hour	1.0E-02	1.0E-02	1.1E-02
Xylenes	1-hour	2.6E-04	2.6E-04	3.1E-04
Mixtures[c]				
Eye irritants	n/a	3.5E-02	3.5E-02	3.6E-02
Nasal irritants	n/a	3.5E-02	3.5E-02	3.6E-02
Respiratory tract irritants	n/a	2.9E-01	2.9E-01	3.1E-01
Hepato- and renal toxicants	n/a	5.1E-04	5.1E-04	6.1E-04
Immunotoxicants	n/a	3.4E-02	3.4E-02	3.4E-02
Neurotoxicants	n/a	5.7E-03	5.7E-03	6.7E-03
Reproductive/ developmental toxicants	n/a	6.7E-04	7.2E-04	7.9E-04

(a) Aliphatic C_{17}-C_{34} group, aromatic C_{17}-C_{34} group, barium, cadmium, carcinogenic PAH groups 1-3, chromium, cobalt, ethylene, manganese, methyl mercury, molybdenum, selenium and zinc were not included in the acute inhalation assessment due to the lack of an adequate acute inhalation exposure limit for the COPCs or, in the case of methyl mercury, it will not be emitted into the air by the Project.

(b) A Risk Quotient equal to or less than 1.0 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. Values in bold show an RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-13.

(d) Health Canada's SUM15 method, which is different from more recent methods and calculates excess health risk when $PM_{2.5}$ air concentrations exceed a daily threshold of 15 µg/m^3 (Health Canada 1999) is provided in Appendix 3-XI (Health Canada's SUM15 Assessment of $PM_{2.5}$ Health Risks).

n/a = Not applicable; averaging-times are not specified for the acute mixtures because the RQ values for the chemical mixtures were based on a combination of acute averaging-times (i.e., 10-minute, 1-hour and 24-hour) depending on the individual COPCs included in the mixture.

3.6.1.1 Sulphur Dioxide

Risk quotients for transient persons at the fence-line MPOI slightly exceeded 1.0 (i.e., 1.2) under the Project Case and PDC based on a 10-minute averaging time. Risk quotients for the Aboriginal and community residents were all below 1.0, indicating that acute SO_2 air concentrations are not expected to result in adverse health effects to people residing in the area.

Interpretation of Results

Interpretation of these exceedances considered:

- the potential contribution from the Project; and
- the degree of conservatism incorporated in the exposure limit.

The RQ values predicted under the Project Case and PDC for transient persons were largely attributable (i.e., approximately 68%) to existing conditions captured under the EAC. The RQ value predicted for transient persons at the fence-line MPOI based on the Project alone is 0.39. This RQ value represents a 48% increase over the predicted EAC risk quotient.

Based on levels at which effects are reported in scientific literature, the highest predicted acute (10-minute) SO_2 concentration at the fence-line MPOI (i.e., 595 µg/m^3) is at the lower end of the range of concentrations where effects were observed in severe asthmatics (Table 3.6-4). There is a 1.7-fold margin of safety between the highest predicted acute SO_2 concentration at the fence-line MPOI and the level at which responses were observed in most individuals, including mild asthmatics engaged in exercise (Table 3.6-4). Highlights are listed below:

- At sufficiently high concentrations, SO_2 acts as an upper respiratory tract irritant. At lower concentrations, it is effectively “scrubbed” by the nose. This scrubbing action effectively prevents the movement of SO_2 further down the respiratory tract, thereby reducing any likelihood of bronchoconstriction and other signs of respiratory distress.
- The response to the irritant action of SO_2 is immediate. Short-term peak exposures are the primary determinants of the response.
- Asthmatic individuals are known to be very sensitive to the irritant effects of SO_2. Exercising asthmatics are especially sensitive. Sensitivity will vary depending on the severity of the asthmatic condition, the level of physical activity and the pattern of breathing (i.e., oral vs. nasal).

- The majority of clinical evidence suggests that most individuals will not notice any response to short-term exposures to concentrations of SO_2 at or below 1,000 µg/m^3. This finding applies even to exercising individuals with mild asthma.
- The threshold of response among severe asthmatics appears to rest between 530 and 1,060 µg/m^3 based on responses observed among freely-breathing asthmatics engaged in moderate exercise.
- For the majority of healthy individuals, responses to SO_2 are unlikely to be noticed by the individual unless concentrations exceed 2,000 µg/m^3, with some evidence to suggest that concentrations as high as 2,600 µg/m^3 can be tolerated without significant discomfort. Above this "threshold" concentration, effects can range from mild respiratory effects among normal individuals during exercise (2,600 to 5,200 µg/m^3) to more severe effects, including irritation and inflammation of the lungs and breathing passages that can progress to a chemical pneumonia (more than 26,000 µg/m^3). The effects of these higher concentrations on the health of asthmatics can be serious and life-threatening.

Table 3.6-4 Potential Health Effects in Humans Associated With Acute Exposure to Sulphur Dioxide

Air Concentration [µg/m^3]	Description of Potential Health Effects[(a)]
<250	No documented reproducible evidence of adverse health effects among healthy individuals or susceptible individuals following short-term exposure.
250 to 530	Possible modest, transient changes in lung function indices, detectable by spirometry, among asthmatics during moderate to strenuous exercise. Changes characterized by increased airway resistance and/or reduced air conductance. All changes fully reversible and strictly sub-clinical in nature, with no evidence of wheezing, shortness of breath or other clinical signs. No documented effects among healthy individuals.
530 to 1,400	Increased likelihood of changes in lung function indices among asthmatics, especially during exercise. Changes characterized by increased airway resistance and/or reduced airway conductance, possibly progressing to evidence of mild broncho-constriction with or without attendant clinical signs depending on severity of asthmatic condition. No effects expected among healthy individuals.
1,400 to 2,500	Further increased likelihood of changes in lung function indices among asthmatics and other sensitive individuals, with distinct possibility of appearance of clinical signs such as shortness of breath, wheezing, difficulty breathing and broncho-constriction. Symptoms could be pronounced among severe asthmatics. Possible modest changes in lung function indices, characterized by increased airway resistance, among healthy individuals, especially while exercising. Changes may be accompanied by mild sore throat, tendency to clear throat and/or mild cough. The ability to taste and smell SO_2 also may begin to appear.
2,500 to 12,500	Increased likelihood of changes in lung function indices among healthy individuals, presenting as increased airway resistance and decreased airway conductance. Changes may be accompanied by clinical signs, including sore throat, cough, headache, nasal congestion and increased salivation. Changes could progress to irritation and inflammation of the breathing passages if exposure is prolonged. Symptoms could persist for several days post-exposure. Very definite possibility of clinical signs consistent with respiratory distress among asthmatics and other sensitive individuals, including wheezing and shortness of breath. Symptoms could be very pronounced, possibly life-threatening, among severe asthmatics, especially if exposure is prolonged. Odour is distinct.

Table 3.6-4 Potential Health Effects in Humans Associated With Acute Exposure to Sulphur Dioxide (continued)

Air Concentration [μg/m^3]	Description of Potential Health Effects[a]
12,500 to 25,000	Very high likelihood of changes in lung function indices among healthy individuals, progressing to sore throat, cough, difficulty breathing and irritation of the breathing passages with prolonged exposure. Possible irritation of the eyes, presenting as increased blinking, tearing, soreness and/or redness. Some possibility of nosebleeds. Pronounced and immediate signs of respiratory distress among asthmatics, including wheezing, shortness of breath, dyspnea and gasping. Condition likely to be disabling and could be life-threatening.
25,000 to 125,000	Frank clinical signs of respiratory distress may appear, including burning of the nose and throat, difficulty breathing, choking, wheezing and dyspnea. Inflammation of the breathing passages may become severe, possibly leading to scarring and chronic airway conditions. A condition known as Reactive Airway Dysfunction Syndrome (RADS) may present secondary to the inflammation of the bronchial passages. Signs of eye irritation, including watery eyes, stinging or burning of the eyes, redness of the eyes and/or eyelids. Skin eruptions (rashes) may be evident if exposure becomes prolonged. Very severe respiratory distress among asthmatics and other individuals suffering from chronic breathing disorders. Condition could be life-threatening.
125,000 to 250,000	Higher incidence and severity of symptoms described above.
> 250,000	Immediately dangerous to life and health. Chemical bronchopneumonia and asphyxia have been reported. Death may result from severe respiratory depression at concentrations approaching 2,500,000 μg/m^3.

[a] Sources: ATSDR (1998); HSDB (2007, Website); IPCS (1979); NIOSH (1974); OEHHA (2007a, Website); WHO (2000, Website).

Alberta Health and Wellness (AHW 2006) examined the potential health effects associated with short-term exposure to low levels of SO_2. The objective of their report was to provide a comprehensive review of the available primary scientific literature to develop a quantitative understanding of the current state of knowledge with respect to the dose-response relationship between exposure to SO_2 and health effects based on the weight of evidence in the peer-reviewed scientific literature.

From their review of clinical human studies, AHW (2006) determined that the weight of evidence for exposures up to 30 minutes suggests that healthy humans can experience exposures to SO_2 up to 26,000 μg/m^3 (10 ppm) with only transitory effects on pulmonary function. Even under challenging conditions involving hyperventilation, mouth-only exposure and heavy exercise, only transitory effects on pulmonary function were observed.

Alberta Health and Wellness (AHW 2006) also states that:

> *The weight of evidence suggests that for single exposures up to four hours and repeated exposures between three days and three weeks, transitory pulmonary effects might occur for asthmatics at exposure concentrations between 0.5 ppm [1,300 μg/m^3] and 1 ppm [2,600 μg/m^3] with exercise and for healthy humans between 0.75 ppm [1,950 μg/m^3] and 25 ppm [65,000 μg/m^3] with exercise, with some evidence for a concentration-dependent response in healthy subjects.*

Based on the available studies and AHW's recent review, the predicted short-term SO_2 concentrations at the fence-line MPOI associated with the Project are not expected to result in adverse health effects to transient persons.

It is important to note that conservative assumptions were incorporated in the exposure assessment. The air dispersion modelling incorporated meteorological data that represent conditions that contribute to maximum predicted air concentrations. In addition, it is unlikely that transient persons would be engaged in traditional or recreational activities along the Project fence-line at the exact time that meteorological conditions would contribute to maximum air concentrations.

Conclusions

Project emissions are predicted to increase the potential health risks associated with short-term (i.e., 10-minute) exposure to SO_2 along the fence-line. Although the predicted RQ values for the Project Case and PDC exceeded 1.0 for transient persons, the weight-of-evidence indicates that there is a low potential for health effects as a result of SO_2.

The weight-of-evidence is as follows:

- Based on levels at which effects are reported in scientific literature, the highest predicted acute (10-minute) SO_2 concentration at the fence-line MPOI (i.e., 595 $\mu g/m^3$) is at the lower end of the range of concentrations where effects were observed in severe asthmatics (i.e., between 530 and 1,060 $\mu g/m^3$);
- There is a 1.7-fold margin of safety between the highest predicted acute SO_2 concentration at the fence-line MPOI and the level at which responses were observed in most individuals, including mild asthmatics engaged in exercise (i.e., 1,000 $\mu g/m^3$);
- From their review of clinical human studies, AHW (2006) determined that the weight of evidence for exposures up to 30 minutes suggests that healthy humans can experience exposures to SO_2 up to 26,000 $\mu g/m^3$ (10 ppm) with transitory effects on pulmonary function, even under challenging conditions involving hyperventilation, mouth-only exposure and heavy exercise; and
- It is unlikely that transient persons would engage in traditional or recreational activities along the Project fence-line at the exact time that meteorological conditions would contribute to maximum SO_2 air concentrations.

3.6.1.2 Residual Impact Classification

Residual impacts for key question HHPDC-1 are classified in Table 3.6-5. Key question HHPDC-1 asked "What are the risks of adverse human health effects from short-term (acute) exposure to air emissions from existing and approved developments, the Project and planned developments?"

The impact classification criteria (e.g., duration, frequency, geographic extent) are already incorporated into the risk estimates and therefore residual impacts are defined by the magnitude of effect as determined from risk estimates. Negligible magnitudes of effect (i.e., chronic inhalation) were predicted for all parameters assessed in the HHRA, with the exception of SO_2. A low magnitude of effect was predicted for SO_2 in the HHRA.

Table 3.6-5 Residual Impact Classification for Key Question HHPDC-1

Parameter	Group at Risk	Magnitude of Effect
SO_2	transient persons	low
All other COPCs	none (parameters met guidelines)	negligible
All mixtures	none (parameters met guidelines)	negligible

3.6.2 Chronic Inhalation Assessment

This section addresses key question HHPDC-2, which asked "What are the risks of adverse human health effects from long-term (chronic) exposure to air emissions and water releases from existing and approved developments, the Project and planned developments?"

Separate assessments were completed for non-carcinogenic and carcinogenic exposures, reflecting the different approaches used in calculating and interpreting the risk estimates.

3.6.2.1 Non-Carcinogens

Interpretation of Results

Chronic inhalation health risks were estimated based on the assumption that an individual is continuously exposed to a predicted annual air concentration. The chronic risk estimates were based on ongoing exposure for an assumed lifespan of 75 years (Health Canada 2004a). Tables 3.6-6 and 3.6-7 present the chronic inhalation health risks for the maximums of the Aboriginal residents and community residents. Transient persons were not included in the chronic inhalation assessment as it was assumed that they would not be exposed on a continuous basis at the Project fenceline. The chronic risk estimates for each of the individual locations are presented in Appendix 3-X (Inhalation Risk Quotients).

Conclusions

Predicted chronic RQ values did not exceed 1.0 for any of the COPCs or mixtures under any of the three assessment cases (i.e., EAC, Project Case and PDC) for Aboriginal and community residents. This demonstrates that in all cases, predicted COPC air concentrations were less than their health-based guidelines. Therefore, health risks for these compounds are considered negligible.

Table 3.6-6 Chronic Inhalation Risk Quotients – Aboriginal Residents

Chemicals of Potential Concern[(a)]	Risk Quotients[(b)]		
	Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_9-C_{16} group	1.8E-03	1.8E-03	2.9E-03
Barium	1.3E-06	2.5E-06	3.0E-06
Carbon disulphide group	1.8E-05	1.8E-05	2.4E-05
Chromium	9.2E-07	1.3E-06	1.4E-06
Cobalt	8.2E-05	8.4E-05	1.1E-04
Copper	2.0E-05	3.4E-05	4.1E-05
Ethylbenzene	4.1E-05	4.1E-05	5.0E-05
Ethylene	2.8E-06	2.8E-06	3.0E-06
Hexane group	3.0E-04	3.1E-04	4.3E-04
Hydrogen sulphide	5.2E-03	5.7E-03	6.6E-03
Mercury	1.6E-05	3.0E-05	3.6E-05
Methyl ethyl ketone group	2.7E-06	2.7E-06	4.0E-06
Molybdenum	2.1E-06	3.6E-06	4.2E-06
Naphthalene group	7.9E-05	1.2E-04	1.6E-04
Nitrogen dioxide	6.4E-02	6.6E-02	8.5E-02
$PM_{2.5}$	5.5E-01	5.5E-01	5.7E-01
Selenium	2.3E-05	2.3E-05	2.3E-05
Sulphur dioxide	8.4E-02	9.0E-02	7.3E-02
Toluene	1.5E-05	1.5E-05	2.3E-05
Trimethylbenzenes	2.2E-06	2.2E-06	3.4E-06
Vanadium	2.5E-03	3.1E-03	3.8E-03
Xylenes	9.2E-04	9.2E-04	1.2E-03
Zinc	9.6E-06	1.6E-05	1.9E-05

Table 3.6-6 Chronic Inhalation Risk Quotients – Aboriginal Residents (continued)

Chemicals of Potential Concern[a]	Risk Quotients[b]		
	Existing and Approved Case	Project Case	Planned Development Case
Mixtures[c]			
Nasal irritants	5.3E-03	5.8E-03	6.7E-03
Respiratory tract irritants	1.3E-01	1.4E-01	1.5E-01
Hepatotoxicants	2.8E-04	2.8E-04	3.7E-04
Renal toxicants	2.7E-04	2.7E-04	3.7E-04
Neurotoxicants	4.0E-03	4.0E-03	5.8E-03
Reproductive/ developmental toxicants	7.0E-05	7.5E-05	9.6E-05

[a] CO and methyl mercury were not included in the chronic inhalation assessment due to either the lack of an adequate chronic inhalation exposure limit for the COPCs or, in the case of methyl mercury, it will not be emitted into the air by the Project. As well, RQs for the aliphatic C2-C8 group, aliphatic C17-C34, aromatic C9-C16, aromatic C17-C34 group, lead and manganese are provided in the multiple pathway assessment as: i) these COPCs were determined to exhibit the potential to persist or accumulate in environmental media and ii) the RfC and RfD for each of these COPCs has the same critical endpoint.

[b] A Risk Quotient equal to or less than 1.0 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. Values in bold show an RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[c] Individual constituents of the chemical mixtures are identified in Table 3.4-12. Note that addition of the individual RQ values provided in the above table for a mixture's chemical constituents might not equate to the RQ value provided for the mixture because the RQ values in the table represent the highest RQ for the lifestyle category. For example, in the EAC, the hydrogen sulphide RQ in the above table is based on predictions at Christina Lake Lodge, while the RQ for the naphthalene group is based on Hunter/Trapper A and the RQ for the "nasal irritants" mixture is based on Christina Lake Lodge.

Table 3.6-7 Chronic Inhalation Risk Quotients – Community Residents

Chemicals of Potential Concern[a]	Risk Quotients[b]		
	Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_9-C_{16} group	6.4E-03	6.4E-03	7.1E-03
Barium	1.5E-06	1.9E-06	2.5E-06
Carbon disulphide group	1.7E-05	1.9E-05	2.3E-05
Chromium	9.3E-07	1.1E-06	1.3E-06
Cobalt	8.8E-05	8.8E-05	1.0E-04
Copper	2.2E-05	2.7E-05	3.5E-05
Ethylbenzene	4.5E-05	4.5E-05	5.5E-05
Ethylene	1.3E-04	1.3E-04	1.3E-04
Hexane group	2.9E-04	2.9E-04	4.1E-04
Hydrogen sulphide	7.8E-03	8.2E-03	9.1E-03
Mercury	1.7E-05	2.3E-05	3.0E-05
Methyl ethyl ketone group	3.7E-05	3.7E-05	3.8E-05
Molybdenum	2.2E-06	2.8E-06	3.6E-06
Naphthalene group	1.0E-04	1.2E-04	1.6E-04
Nitrogen dioxide	6.2E-02	6.5E-02	7.9E-02
$PM_{2.5}$	5.4E-01	5.4E-01	5.6E-01
Selenium	2.1E-05	2.1E-05	2.1E-05
Sulphur dioxide	8.4E-02	9.3E-02	7.7E-02
Toluene	5.7E-05	5.7E-05	6.5E-05
Trimethylbenzenes	4.2E-06	4.2E-06	5.6E-06
Vanadium	2.3E-03	2.5E-03	3.3E-03
Xylenes	1.6E-03	1.6E-03	1.9E-03
Zinc	1.0E-05	1.3E-05	1.6E-05

Table 3.6-7 Chronic Inhalation Risk Quotients – Community Residents (continued)

Chemicals of Potential Concern[a]	Risk Quotients[b]		
	Existing and Approved Case	Project Case	Planned Development Case
Mixtures[c]			
Nasal irritants	7.9E-03	8.3E-03	9.2E-03
Respiratory tract irritants	1.3E-01	1.5E-01	1.5E-01
Hepatotoxicants	5.5E-04	5.5E-04	6.5E-04
Renal toxicants	5.3E-04	5.3E-04	6.3E-04
Neurotoxicants	9.6E-03	9.6E-03	1.1E-02
Reproductive/ developmental toxicants	1.0E-04	1.0E-04	1.2E-04

(a) CO and methyl mercury were not included in the chronic inhalation assessment due to either the lack of an adequate chronic inhalation exposure limit for the COPCs or, in the case of methyl mercury, it will not be emitted into the air by the Project. As well, RQs for the aliphatic C2-C8 group, aliphatic C17-C34, aromatic C9-C16, aromatic C17-C34 group, lead and manganese are provided in the multiple pathway assessment as: i) these COPCs were determined to exhibit the potential to persist or accumulate in environmental media and ii) the RfC and RfD for each of these COPCs has the same critical endpoint.

(b) A Risk Quotient equal to or less than 1.0 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. Values in bold show an RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-12.

3.6.2.2 Carcinogens

Interpretation of Results

Tables 3.6-8 and 3.6-9 present the maximum chronic inhalation health risks for the Aboriginal residents and community residents. Transient persons were not included in the chronic inhalation assessment as it was assumed that they would not be exposed on a continuous basis at the Project fenceline. Risk estimates for each individual location are presented in Appendix 3-X (Inhalation Risk Quotients).

As discussed, the regulatory benchmark of an acceptable incremental lifetime cancer risk of 1 in 100,000 is policy-based (AENV 2001; AHW 2007; CCME 2006; Health Canada 2004a). Since regulators have not recommended an acceptable cancer incidence rate (or LCR) for exposure to carcinogens associated with background or “baseline” conditions, interpretation of the significance of the EAC LCR values should not be based on the regulatory “benchmark” of 1 in 100,000. Regardless, predicted LCR values for the EAC did not exceed 1.0 for the Aboriginal and community residents, signifying that lifetime exposure to background levels of carcinogens via inhalation would theoretically result in less than one cancer case when calculated on a 100,000 person population basis.

Conclusions

As shown in Tables 3.6-8 and 3.6-9, the maximum predicted ILCR values associated with the Project (i.e., Project Case minus EAC) and Future Emission Sources in the area (i.e., PDC minus EAC) are all less than 1 in 100,000, indicating that the incremental cancer risk from the Project and planned developments is deemed to be "essentially negligible" (Health Canada 2004a).

Table 3.6-8 Chronic Inhalation Lifetime and Incremental Lifetime Cancer Risks per 100,000 – Aboriginal Residents

Chemicals of Potential Concern	Lifetime Cancer Risk[(a)]	Incremental Lifetime Cancer Risk[(b)]	
	Existing and Approved Case	Project Emission Sources (Project Case – EAC)	Future Emission Sources (PDC – EAC)
Arsenic	2.9E-03	2.4E-03	3.3E-03
Benzene	9.5E-03	4.2E-05	2.9E-03
Beryllium	7.3E-05	5.9E-05	8.0E-05
Cadmium	4.9E-03	3.6E-03	5.7E-03
Carcinogenic PAH group 1	1.7E-05	1.6E-05	2.7E-05
Carcinogenic PAH group 2	8.1E-07	5.9E-07	1.0E-06
Carcinogenic PAH group 3	1.1E-07	7.3E-08	1.2E-07
Chromium VI	4.2E-02	2.1E-02	2.9E-02
Formaldehyde	3.7E-02	1.3E-03	7.0E-03
Nickel	1.9E-02	5.3E-03	9.3E-03
Mixtures[(c)]			
Lung carcinogens	6.8E-02	3.3E-02	4.8E-02
Acceptable Incremental Lifetime Cancer Risk	*n/a*	*1*	*1*

[(a)] Lifetime cancer risks refer to the number of cancer cases that could potentially result from the estimated exposures to the carcinogenic COPCs among a population of 100,000 people. Since an acceptable cancer incidence rate has not been recommended for exposure to carcinogens associated with anything other than the Project and Future Emission Sources by any leading scientific or regulatory authority, interpretation of the significance of the LCR values determined for the EAC could be not based on comparison against a numerical "benchmark" of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[(b)] An ILCR equal to or less than 1.0 signifies an incremental lifetime cancer risk that is below the benchmark ILCR of one in 100,000 (i.e., within the generally accepted limit deemed to be protective of public health). Boldface values show an ILCR of greater than the de minimus risk level of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[(c)] Individual constituents of the chemical mixtures are identified in Table 3.4-12. Note that addition of the individual LCR and ILCR values provided in the above table for a mixture's chemical constituents might not equate to the LCR and ILCR values provided for the mixture because the LCR and ILCR values in the table represent the highest values for the lifestyle category. For example, in the EAC, the arsenic LCR in the above table is based on predictions at Hunter/Trapper A, while the LCR for hexavalent chromium is based on Janvier/Chard (IR 194) and the LCR for the "lung carcinogens" mixture is based on Janvier/Chard (IR 194).

n/a = Not applicable.

Table 3.6-9 Chronic Inhalation Lifetime and Incremental Lifetime Cancer Risks per 100,000 – Community Residents

Chemicals of Potential Concern	Lifetime Cancer Risk[a]	Incremental Lifetime Cancer Risk[b]	
	Existing and Approved Case	Project Emission Sources (Project Case – EAC)	Future Emission Sources (PDC – EAC)
Arsenic	3.2E-03	8.0E-04	1.8E-03
Benzene	2.1E-01	1.4E-05	2.4E-03
Beryllium	7.9E-05	1.9E-05	4.4E-05
Cadmium	5.2E-03	1.2E-03	3.5E-03
Carcinogenic PAH group 1	2.4E-05	5.6E-06	1.6E-05
Carcinogenic PAH group 2	1.1E-06	2.0E-07	6.5E-07
Carcinogenic PAH group 3	1.5E-07	2.5E-08	7.6E-08
Chromium VI	4.3E-02	6.9E-03	1.6E-02
Formaldehyde	2.7E-01	4.4E-04	5.9E-03
Nickel	1.9E-02	1.7E-03	6.2E-03
Mixtures[c]			
Lung carcinogens	7.0E-02	1.1E-02	2.8E-02
Acceptable Incremental Lifetime Cancer Risk	*n/a*	*1*	*1*

[a] Lifetime cancer risks refer to the number of cancer cases that could potentially result from the estimated exposures to the carcinogenic COPCs among a population of 100,000 people. Since an acceptable cancer incidence rate has not been recommended for exposure to carcinogens associated with anything other than the Project and Future Emission Sources by any leading scientific or regulatory authority, interpretation of the significance of the LCR values determined for the EAC could be not based on comparison against a numerical “benchmark” of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[b] An ILCR equal to or less than 1.0 signifies an incremental lifetime cancer risk that is below the benchmark ILCR of one in 100,000 (i.e., within the generally accepted limit deemed to be protective of public health). Boldface values show an ILCR of greater than the de minimus risk level of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[c] Individual constituents of the chemical mixtures are identified in Table 3.4-12.

n/a = Not applicable.

3.6.2.3 Residual Impact Classification

Residual impacts for key question HHPDC-2 are classified in Table 3.6-10. Key question HHPDC-2 asked “What are the risks of adverse human health effects from long-term (chronic) exposure to air emissions and water releases from existing and approved developments, the Project and planned developments?”

The impact classification criteria (e.g., duration, frequency, geographic extent) are already incorporated into the risk estimates and therefore residual impacts are defined by the magnitude of effect as determined from risk estimates. Negligible magnitudes of effect (i.e., chronic inhalation) were predicted for all parameters assessed in the HHRA.

Table 3.6-10 Residual Impact Classification for Key Question HHPDC-2

Parameter	Group at Risk	Magnitude of Effect
all COPCs	none (parameters met guidelines)	negligible
all mixtures	none (parameters met guidelines)	negligible

3.6.3 Chronic Multiple Pathway Assessment

This section also addresses key question HHPDC-2, which asked "What are the risks of adverse human health effects from long-term (chronic) exposure to air emissions and water releases from existing and approved developments, the Project and planned developments?"

As in the chronic inhalation assessment, separate assessments were completed for non-carcinogenic and carcinogenic exposures, reflecting the different approaches used in calculating and interpreting the risk estimates.

Predicted health risks associated with multiple pathways of exposure (i.e., inhalation, ingestion and dermal contact), presented as RQs for the non-carcinogens, are summarized in Tables 3.6-11 and 3.6-12, and as LCRs and ILCRs for carcinogens, in Tables 3.6-19 and 3.6-20. Risk estimates are provided for the Aboriginal residents and community residents, considering all potential routes of exposure. It was assumed that individuals would be exposed continuously for a lifetime (i.e., 75 years).

The multiple pathway assessment focused on those COPCs emitted into the air with the potential to persist or accumulate in the environment. In total, potential health risks associated with exposure through multiple pathways were considered for the persistent VOCs, PAHs and metals emitted by the Project (Table 3.4-8).

3.6.3.1 Non-Carcinogens

The risk estimates, presented as RQ values, are provided for the most sensitive life stage for each of the lifestyle categories. The most sensitive life stage is defined as the life stage with the greatest exposure per unit body weight per day (Health Canada 2004a). On this basis, young children were typically identified as the most sensitive on a per unit body weight basis.

The predicted chronic multiple pathway RQ values (Tables 3.6-11 and 3.6-12) did not exceed 1.0 for most COPCs in most instances, with the following exceptions:

- manganese;
- methyl mercury;
- zinc;
- haematological toxicants;
- neurotoxicants; and
- reproductive/developmental toxicants.

The predicted RQ values that exceeded 1.0 are discussed below.

Table 3.6-11 Chronic Risk Quotients From Multiple Pathways of Exposure – Aboriginal Residents

Chemicals of Potential Concern[a]	**Risk Quotient[b]**		
	Existing and Approved Case	**Project Case**	**Planned Development Case**
Aliphatic C_2-C_8 group	8.5E-04	8.5E-04	1.0E-03
Aliphatic C_9-C_{16} group	2.1E-01	2.1E-01	2.3E-01
Aliphatic C_{17}-C_{34} group	1.6E-02	1.6E-02	2.4E-02
Aromatic C_9-C_{16} group	7.1E-04	7.1E-04	9.4E-04
Aromatic C_{17}-C_{34} group	3.3E-07	3.3E-07	3.5E-07
Barium	1.2E-01	1.2E-01	1.2E-01
Beryllium	8.7E-04	8.7E-04	8.7E-04
Cadmium	5.6E-03	5.7E-03	5.7E-03
Chromium	5.9E-04	5.9E-04	5.9E-04
Chromium VI	5.8E-03	5.9E-03	6.0E-03
Copper	2.3E-02	2.3E-02	2.3E-02
Lead	1.1E-02	1.1E-02	1.1E-02
Manganese	7.6E-01	7.6E-01	7.6E-01
Mercury	1.4E-01	1.4E-01	1.4E-01
Methyl mercury	**5.9E+00**	**5.9E+00**	**5.9E+00**
Molybdenum	1.3E-02	1.3E-02	1.3E-02
Naphthalene group	3.4E-05	3.4E-05	3.5E-05
Nickel	7.9E-02	7.9E-02	7.9E-02
Selenium	2.9E-02	2.9E-02	2.9E-02
Vanadium	2.7E-02	2.7E-02	2.7E-02
Zinc	**4.5E+00**	**4.5E+00**	**4.5E+00**
Mixtures[c]			
Hepatotoxicants	2.2E-01	2.2E-01	2.6E-01
Renal toxicants	1.2E-01	1.2E-01	1.2E-01
Haematological toxicants	**4.7E+00**	**4.7E+00**	**4.8E+00**
Neurotoxicants	**6.7E+00**	**6.7E+00**	**6.7E+00**
Reproductive/ developmental toxicants	**6.0E+00**	**6.0E+00**	**6.0E+00**

(a) Cobalt was not included in the chronic multiple pathway assessment due to the lack of an adequate chronic oral exposure limit for cobalt.

(b) An RQ equal to or less than 1.0 signifies that the estimated exposure is less than the exposure limit and no health effects are expected. Boldface values show a RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-12.

Table 3.6-12 Chronic Risk Quotients From Multiple Pathways of Exposure – Community Residents

Chemicals of Potential Concern[a]	Risk Quotients[b]		
	Existing and Approved Case	**Project Case**	**Planned Development Case**
Aliphatic C_2-C_8 group	9.0E-04	9.1E-04	1.0E-03
Aliphatic C_9-C_{16} group	2.0E-01	2.0E-01	2.3E-01
Aliphatic C_{17}-C_{34} group	4.0E-01	4.0E-01	4.1E-01
Aromatic C_9-C_{16} group	5.9E-04	5.9E-04	7.1E-04
Aromatic C_{17}-C_{34} group	3.4E-07	3.5E-07	3.7E-07
Barium	2.0E-01	2.0E-01	2.0E-01
Beryllium	5.4E-04	5.4E-04	5.4E-04
Cadmium	7.8E-03	7.9E-03	7.9E-03
Chromium	6.1E-04	6.1E-04	6.1E-04
Chromium VI	8.1E-03	8.1E-03	8.2E-03
Copper	2.6E-02	2.6E-02	2.6E-02
Lead	1.2E-02	1.2E-02	1.2E-02
Manganese	**2.5E+00**	**2.5E+00**	**2.5E+00**
Mercury	1.5E-01	1.5E-01	1.5E-01
Methyl mercury	**5.9E+00**	**5.9E+00**	**5.9E+00**
Molybdenum	1.2E-02	1.2E-02	1.2E-02
Naphthalene group	3.5E-05	3.6E-05	3.7E-05
Nickel	8.0E-02	8.0E-02	8.0E-02
Selenium	2.7E-02	2.7E-02	2.7E-02
Vanadium	2.3E-02	2.4E-02	2.4E-02
Zinc	**4.5E+00**	**4.5E+00**	**4.5E+00**
Mixtures[c]			
Hepatotoxicants	6.0E-01	6.0E-01	6.3E-01
Renal toxicants	2.0E-01	2.0E-01	2.0E-01
Haematological toxicants	**4.7E+00**	**4.7E+00**	**4.7E+00**
Neurotoxicants	**8.4E+00**	**8.4E+00**	**8.4E+00**
Reproductive/ developmental toxicants	**6.0E+00**	**6.0E+00**	**6.0E+00**

(a) Cobalt was not included in the chronic multiple pathway assessment due to the lack of an adequate chronic oral exposure limit for cobalt.

(b) An RQ equal to or less than 1.0 signifies that the estimated exposure is less than the exposure limit and no health effects are expected. Boldface values show a RQ of greater than 1.0. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-12.

Manganese

Risk quotients for manganese exceeded 1.0 (i.e., 2.5) for the community residents under all three assessment cases (Table 3.6-12). Risk quotients for the Aboriginal residents were all below 1.0, indicating that no potential health risks are predicted from multiple pathways of exposure for Aboriginal residents.

Interpretation of Results

Interpretation of these exceedances considered:

- the potential contribution from the Project;
- the primary exposure pathway contributing to these predicted exceedances; and
- the degree of conservatism incorporated in the exposure assessment and exposure limit.

The Project is expected to have little influence on the exceedances predicted for manganese. There is no predicted change between the RQ values under the EAC and the Project Case for community residents. The RQ value predicted for community residents based on the Project alone is 0.000063. This RQ value represents a 0.0025% increase over the predicted EAC risk quotient. As such, the risk estimates predicted under the Project Case are entirely due to the existing conditions captured under the EAC. Similarly, there is no predicted change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are entirely due to the existing conditions captured under the EAC.

The primary exposure pathways contributing to the EAC RQ values are shown in Table 3.6-13. As shown, health risks associated with manganese are primarily due to baseline concentrations in vegetation.

Table 3.6-13 Contribution of Individual Exposure Pathways to Potential Risk Quotients for Manganese

Exposure Pathway	Percent Contribution [%]
ingestion of leafy vegetation	98
ingestion of root vegetables	0.1
ingestion of fruit	2.0

Manganese concentrations measured in Labrador tea samples collected from the Project area are high relative to measured concentrations of manganese in Labrador tea samples collected from other projects in the region. The measured concentrations of manganese in Labrador tea samples collected from the Project area ranged from 203 to 1,150 mg/kg (95 UCLM of 987 mg/kg). Where as, the measured concentrations of manganese from Canadian Natural's Kirby In-Situ Oil Sands Project and Primrose East Project areas ranged from 220 to 632 mg/kg (95 UCLM of 406 mg/kg). Use of the 95 UCLM from the Kirby data set would result in a more than two-fold decrease in the risk estimates for manganese. For further information on the ambient data, refer to Appendix 3-IX (Regional Environmental Sampling Data).

The RQ values for manganese are likely overstated due, in part, to the incorporation of conservative assumptions in the toxicity assessment. The oral exposure limit used in the multiple pathway assessment was recommended by U.S. EPA (1996, Website); however, the level at which adverse effects of oral manganese exposure would be observed has not been identified, to date. As such, a NOAEL was derived by the U.S. EPA using toxicity data obtained from large populations consuming normal diets over an extended period of time with no report of adverse health effects (U.S. EPA 1996, Website). The WHO (2004) noted in its toxicological review that manganese is not considered very toxic to humans given the existence of homeostatic mechanisms and that the incidence of adverse health effects at the upper range of dietary intake is negligible. Manganese is an essential element required for enzyme co-factors and is a constituent of metalloenzymes.

Further conservatism was incorporated into the multiple pathway assessment for manganese via the following exposure assumptions:

- Residents would be exposed to the 95 UCLM concentration in all environmental media, including soil, vegetation, water, sediment and fish every day over a 75-year period.
- Tissue concentrations from local wild game were based on the maximum predicted ground-level air concentrations of all discrete receptor locations, including the fence-line MPOI. It is unlikely that wild game would forage at one discrete location over their entire lifetime and be exposed to maximum concentrations predicted in air, soil, water and vegetation.
- Predicted environmental media concentrations were based on 75 years of continuous Project emissions and associated chemical deposition despite the expected operational life of the Project (i.e., 34 years). It was assumed that no degradation of the COPCs would occur over time.
- Community residents would obtain 100% of their wild game and fish and 10% of their fruits and vegetables from local sources.

Conclusions

Project emissions are predicted to have minimal impact on the potential health risks associated with long-term exposure to manganese in the region as there was no predicted change in the EAC and Project Case RQ values. The maximum Project only RQ value was 0.000063 for the residents living in nearby communities, representing less than a 0.0025% increase over the EAC predictions. Similarly, a negligible change in manganese-related health risk was predicted for the EAC and PDC.

Although the predicted RQ values for manganese exceeded 1.0, the weight-of-evidence indicates that there is low potential for health impacts in the region as a result of chemical emissions. The weight-of-evidence is as follows:

- Most of the manganese RQ values under the EAC were the result of the baseline vegetation concentrations used in the HHRA. The measured concentrations of manganese in Labrador tea used to characterize baseline plant concentrations were high relative to other samples collected in the region.
- The RQ values are based on conservative assumptions incorporated in the toxicity assessment and exposure assessment of the HHRA.

Methyl Mercury

Risk quotients for methyl mercury exceeded 1.0 (i.e., 5.9) for the Aboriginal and community residents under all three assessment cases (Tables 3.6-11 and 3.6-12).

Interpretation of Results

Interpretation of these exceedances considered:

- the potential contribution from the Project;
- the primary exposure pathway contributing to these predicted exceedances; and
- the degree of conservatism incorporated in the assumed consumption patterns and exposure limit.

The Project is expected to have little influence on the exceedances predicted for methyl mercury. There is no predicted change between the RQ values under the EAC and the Project Case for both Aboriginal and community residents. As such, the risk estimates predicted under the Project Case are entirely due to the existing conditions captured under the EAC. Similarly, there is no change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are also entirely due to the existing conditions captured under the EAC.

The primary exposure pathways contributing to the EAC RQ values are provided in Table 3.6-14. As shown, risks associated with methyl mercury are primarily due to baseline (i.e., EAC) concentrations in fish. Given that fish tissue concentrations were not measured in the Project area, literature-derived bioconcentration factors (BCFs) and measured surface water concentrations were used to predict baseline fish tissue concentrations. The highest predicted RQ values are associated with a predicted methyl mercury concentration of 0.44 ppm in fish (under the EAC, Project Case and PDC), which meets the Health Canada retail consumption guideline of 0.5 ppm.

Health Canada's current retail consumption guideline for mercury in fish of 0.5 ppm is one of the most stringent and protective in the world (Health Canada 2007, Website). For certain predatory fish (e.g., shark, swordfish, fresh and frozen tuna), which tend to have higher levels of mercury because of their relative size, lifespan and diet, Health Canada requires that tissue concentrations meet a new standard of 1.0 ppm (Health Canada 2007, Website). These standards are intended to ensure that the health of Canadians is protected from the toxic effects of methyl mercury (Health Canada 2007, Website).

Table 3.6-14 Contribution of Individual Exposure Pathways to Potential Risk Quotients for Methyl Mercury

Exposure Pathway	Percent Contribution [%]	
	Aboriginal Resident	Community Resident
ingestion of soil (inadvertent)	0	0
ingestion of water	0	0
ingestion of leafy vegetation	0	0
ingestion of root vegetables	0	0
ingestion of fruit	0	0
ingestion of fish	100	100
ingestion of wild game	0	0

The predicted methyl mercury concentration in fish of 0.44 ppm is at the higher end of the range of mercury concentrations measured in fish collected from other regions in North America. The predicted fish tissue concentration for methyl mercury falls within the range of mercury concentrations measured in fish collected from the Athabasca and Muskeg rivers. Mercury concentrations measured in fish collected from waterbodies in Canada and the United States are listed in Table 3.6-15.

Table 3.6-15 Measured Mercury Concentrations in Freshwater Fish Collected in North America

Fish concentration [ppm]	Description[a]
Canada	
0.03 to 0.84	Concentrations measured in longnose sucker, lake whitefish, walleye and northern pike collected from the Athabasca River and Muskeg River.
0.013 to 0.10	Concentrations measured in yellow perch from Canadian Natural's Kirby In-Situ Oil Sands and Primrose East Project areas.
0.4 to 1.3	Concentrations measured in walleye and pike collected from waterbodies in northwestern Ontario.
0.04 to 0.28	Concentrations measured in whitefish collected from waterbodies in northwestern Ontario.
0.02 to 0.28	Concentrations measured in 64 whitefish by the Canadian Food Inspection Agency (CFIA) at processing plants during the periods April 1, 2002 to March 31, 2003 and April 1, 2003 to October 7, 2004.
0.01 to 0.56	Concentrations measured in 86 trout (lake and rainbow) by the Canadian Food Inspection Agency (CFIA) at processing plants during the periods April 1, 2002 to March 31, 2003 and April 1, 2003 to October 7, 2004.
United States	
0.23 to 1.65	Concentrations measured in panfish aged 2 to 10+ years collected from 12 Adirondack lakes.
0.01 to 0.19	Concentrations measured in yellow perch collected from 16 New York lakes.
0.05 to 1.45	Concentrations measured in pike/pickerel, panfish and trout collected from 42 New Jersey lakes and rivers.
0.16 to 1.74	Concentrations measured in walleye collected from 38 Wisconsin lakes.
0.19 to 1.00	Concentrations measured in walleye collected from 34 Northern Wisconsin lakes.

[a] Source: RAMP (2007, Website); Health Canada (1986; 2007, Website); U.S. EPA (1997); Canadian Natural (2008)

For comparative purposes, RQ values were also predicted using a measured methyl mercury concentration of 0.048 ppm (95 UCLM) in fish collected from waterbodies in Canadian Natural's Kirby In-Situ Oil Sands and Primrose East Project areas. Based on this tissue concentration, predicted RQ values did not exceed 1.0 (an RQ value of 0.64 was predicted for Aboriginal and community residents). The RQ value of 0.64 based on measured fish tissue concentrations from the region is nine times lower than the RQ value of 5.9 based on the predicted fish tissue concentrations using a combination of measured surface water data from the Project area and the literature-derived bioconcentration factor.

Fish consumption is associated with significant health benefits as well as potential health risks due to methyl mercury contamination. Health Canada (2007, Website) notes that fish is an excellent source of high quality protein and one of the best food sources of omega-3 fatty acids, which are required in the diet and important to heart health and brain and eye development. Fish is also the most significant source of naturally occurring Vitamin D and it contributes valuable minerals such as selenium, iodine, magnesium, iron and copper to the diet (Health Canada 2007, Website). A recent clinical review of the relative risks and benefits of fish consumption concluded that for major health outcomes among adults, the benefits of fish intake exceed the potential risks (Mozaffarian and Rimm 2006). This was true even for women of childbearing age, excepting a few selected fish species that accumulate methyl mercury to a higher degree (e.g., predator fish like albacore tuna, shark and swordfish). Health Canada (2007, Website) concluded that fish consumers should receive balanced information that will allow them to make fish choices that optimize the nutritional benefits and minimize the risks from mercury exposure.

Conservatism was also introduced into the toxicity assessment of methyl mercury. The HHRA adopted an oral exposure limit for methyl mercury of 0.1 µg/kg bw/d that is currently recommended by the U.S. EPA (2001, Website). However, Health Canada (2007, Website) has recently adopted a provisional Total Daily Intake (pTDI) of 0.2 µg/kg bw/d for women of child-bearing age and young children. The pTDI is protective of the increased susceptibility of the developing fetus and young children to the effects of methyl mercury.

The pTDI was derived based on a 10 ppm maternal hair methyl mercury level as the approximate threshold for neuropsychological effects (Grandjean et al. 1997). This value was first converted to a corresponding blood methyl mercury level and then to a dietary methyl mercury intake level using an equation employed by the U.S. EPA (2001, Website). A 5-fold uncertainty factor was applied to this intake level to obtain a pTDI of methyl mercury for women of child-bearing age and young children of 0.2 µg/kg bw/d (Feeley and Lo 1998, Website; Health Canada 2007, Website). Health Canada also provides a TDI 0.47 µg/kg bw/d for the general adult population (Health Canada 2007, Website).

Currently, mercury levels measured in fish caught from the local lakes are low (0.048 ppm, Canadian Natural 2008), suggesting that the benefits of eating fish from the region likely outweigh any associated health risks.

Conclusions

Project emissions are predicted to have minimal effects on the potential health risks associated with long-term exposure to methyl mercury in the region as there was no change in the RQ values between the EAC and the Project Case. Similarly, no change in the RQ values was predicted for the EAC and PDC.

Although the predicted RQ values for methyl mercury exceeded 1.0, the weight-of-evidence indicates that there is low potential for health effects in the region as a result of mercury emissions. The weight-of-evidence is as follows:

- The methyl mercury RQ values under the EAC were the result of assumed fish concentrations. The predicted concentration of methyl mercury in fish for the EAC is likely a conservative estimate given that the predicted concentration falls at the higher end of the range of mercury fish concentrations measured in Canada and the United States. Further, RQ values predicted for the Project using measured methyl mercury concentrations in fish collected from the region (as opposed to predicted fish concentrations based on measured surface water data from the Project area) did not exceed 1.0.
- The RQ values were derived based on a highly conservative oral exposure limit which likely overstates the potential risk associated with methyl mercury.

Zinc

Risk quotients for zinc exceeded 1.0 (i.e., 4.5) for the Aboriginal and community residents under all three assessment cases (Tables 3.6-11 and 3.6-12).

Interpretation of Results

Interpretation of these exceedances considered:

- the potential contribution from the Project;
- the primary exposure pathway contributing to these predicted exceedances; and
- the degree of conservatism incorporated in the assumed consumption patterns and exposure limit.

The Project is expected to have no influence on the exceedances predicted for zinc as there is no predicted change between the assessed RQ values under the EAC and the Project Case for both the Aboriginal and community residents. The RQ value predicted for Aboriginal residents based on the Project alone is 0.000012. This RQ value represents a 0.00026% increase over the predicted EAC RQ. As such, the risk estimates predicted under the Project Case are entirely due to the existing conditions captured under the EAC. Similarly, there is no predicted change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are entirely due to the existing conditions captured under the EAC.

The RQ value predicted for community residents based on the Project alone is 0.0000083. This RQ value represents a 0.00018% increase over the predicted EAC RQ. As such, the risk estimates predicted under the Project Case are entirely due to the existing conditions captured under the EAC. In addition, there is negligible change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are entirely due to the existing conditions captured under the EAC.

The primary exposure pathways contributing to the EAC RQ values for toddlers are shown in Table 3.6-16. Risks associated with zinc are primarily due to predicted baseline (i.e., EAC) concentrations in fish.

Table 3.6-16 Contribution of Individual Exposure Pathways to Potential Risk Quotients for Zinc

Exposure Pathway	Percent Contribution [%]	
	Aboriginal Resident	Community Resident
ingestion of soil (inadvertent)	0	0
ingestion of water	1.3	0
ingestion of leafy vegetation	0	0.2
ingestion of root vegetables	0	0.1
ingestion of fruit	0.1	0
ingestion of fish	98	99
ingestion of wild game	0.2	0.2

Measured zinc concentrations in fish were not available for the Project area. Thus, fish concentrations were predicted using a literature-derived BCF value and measured surface water concentrations. The BCF values are intended to be used with dissolved phase water concentrations (U.S. EPA OSW 2005). To remain conservative, total surface water concentrations were used to calculate fish tissue concentrations in the HHRA. This likely contributed to the overestimation of zinc concentrations in fish.

The 95 UCLM zinc concentration in surface water of 0.49 mg/L was used to predict fish tissue concentrations. Surface water concentrations measured in waterbodies from the region are generally much lower than the measured surface water concentrations from the Project area. For instance, zinc concentrations in surface water collected from the Muskeg and Athabasca rivers ranged from 0.0011 to 0.15 mg/L (RAMP 2007, Website). Surface water samples collected from waterbodies in Canadian Natural’s Kirby In-Situ Oil Sands and Primrose

East Project areas identified zinc concentrations in the range of 0.004 to 0.032 mg/L, with a 95 UCLM of 0.018 mg/L (Canadian Natural 2008).

The predicted zinc concentration in fish of 1,000 ppm is considerably higher than the range of zinc concentrations measured in fish collected from other regions in North America. The maximum measured zinc concentration in fish collected in support of the Canadian Natural's Kirby and Primrose East projects is 43 times lower than the predicted zinc concentration for the MEG Project, indicating that zinc concentrations in fish are likely overestimated for the current HHRA (Canadian Natural 2008). For comparison, zinc concentrations measured in fish collected from waterbodies in Canada and the United States are listed in Table 3.6-17.

Table 3.6-17 Measured Zinc Concentrations in Freshwater Fish Collected in North America

Fish Concentration [ppm]	Description[(a)]
Canada	
2.6 to 9.6	Concentrations measured in lake whitefish, walleye and northern pike collected from the Athabasca River and Muskeg River.
6.3 to 23.4	Concentrations measured in yellow perch from Canadian Natural's Kirby In-Situ Oil Sands and Primrose East Project areas.
United States	
21.7	Geometric mean concentration measured in various whole fish as part of the National Contaminant Biomonitoring Program.
4.6 to 28	Range of mean levels measured in muscle tissue of fish collected from aquatic systems in east Tennessee.
21.2 to 30.7	Range of mean levels measured in redear sunfish, largemouth bass and bluegill sunfish collected from lakes and ponds in Orlando.

(a) Source: RAMP (2007, Website); ATSDR (2005a); Canadian Natural (2008).

It appears that the high measured zinc concentrations in surface water from the Project area contributed to higher predicted fish concentrations relative to actual concentrations measured in fish from the region. To provide a comparison, RQ values were predicted for the Project using a measured zinc concentration of 16.6 ppm (95 UCLM) in fish collected from waterbodies in Canadian Natural's Kirby In-Situ Oil Sands and Primrose East Project areas. Based on this measured fish tissue concentration, predicted RQ values did not exceed 1.0.

Using measured fish data, an RQ value of 0.15 was predicted for Aboriginal residents and an RQ value of 0.097 was predicted for community residents. These RQ values are 30 to 45 times lower than the RQ value of 4.5, which is based on predicted fish tissue concentrations using a combination of measured surface water data from the Project area and a literature-based bioconcentration factor.

Conservative assumptions were incorporated in the selection of the oral exposure limit for zinc. The HHRA adopted an oral exposure limit of 300 µg/kg bw/d that is currently recommended by the U.S. EPA (2005, Website). The oral exposure limit is based on decreases in erythrocyte copper, zinc-superoxidase dismutase (ESOD) activity reported in four separate studies conducted in male and female volunteers (U.S. EPA 2005, Website). The average daily intakes were added to the reported supplemental doses to determine the total doses, which were then adjusted by body weight to derive the effect levels. The U.S. EPA (2005, Website) applied an uncertainty factor of three to account for intra-species variability, but did not apply an uncertainty factor for use of a subchronic study in recognition of the fact that zinc is an essential nutrient and thus chronic exposure is required for proper nutrition (U.S. EPA 2005, Website). The relevance of the endpoint (decrease in ESOD activity) has been questioned, considering that other enzymes also serve to detoxify superoxide within the body. As stated by ATSDR (2005a), “the overall effect of reducing the levels of an isoform of superoxide dismutase on the body’s ability to detoxify superoxide radicals is therefore uncertain.”

An uncertainty factor for use of a LOAEL was not incorporated as the RfD is based on a minimal effect level for a sensitive biological indicator (U.S. EPA 2005, Website). The U.S. EPA (2005, Website) also did not apply an uncertainty factor greater than three for intra-species variability as this would result in an exposure limit lower than the daily requirement for sensitive humans.

Health Canada (2006b, Website) provides Recommended Dietary Allowances (RDAs) of 250 to 300 µg/kg bw/d for infants and young children. The RDA refers to the average daily dietary intake level that is sufficient to meet the nutrient requirement of 97 to 98% of healthy individuals in a particular life stage and gender group (Health Canada 2006b, Website). Health Canada (2006b, Website) also established Tolerable Upper Intake Levels (ULs) for zinc of 560 to 690 µg/kg bw/d depending on the life stage and gender group. The UL is the highest average daily nutrient intake level likely to pose no risk of adverse health effects to almost all individuals in a given life stage and gender group (Health Canada 2006b, Website). Health Canada (2006b, Website) warns that as intake increases above the UL, the potential risk of adverse effects increases. The RIVM (2001) also considers the daily requirement of zinc to be 300 µg/kg bw/d and recommends an oral exposure limit of 500 µg/kg bw/d for zinc.

The maximum predicted total exposure to zinc is 1,360 µg/kg bw/d and 1,350 µg/kg bw/d for Aboriginal and community residents, respectively. Using the ULs recommended by Health Canada, RQ values of 2.0 to 2.4 are calculated for Aboriginal and community residents. In light of the fact that fish tissue concentrations are likely overstated, RQ values for Aboriginal and community residents are actually expected to be much less than 1.0.

Conclusions

Project emissions are predicted to have minimal effects on the potential health risks associated with long-term exposure to zinc in the region as there was no predicted change between the EAC and the Project Case RQ values. Similarly, no changes in the RQ values were predicted for the EAC and PDC Case.

Although the predicted RQ values for zinc exceeded 1.0, the weight-of-evidence indicates that there is low potential for health impacts in the region as a result of chemical emissions. The weight-of-evidence is as follows:

- The zinc RQ values under the EAC were due to the assumed fish concentrations. The predicted concentration of zinc in fish for the EAC is likely a conservative estimate given that the predicted concentration is much higher than zinc concentrations measured in fish collected from the region and in the United States. Further, RQ values predicted for the Project using measured zinc concentrations in fish collected from the region as opposed to predicted fish concentrations based on measured surface water data from the Project area did not exceed 1.0.
- Although BCF values are intended to be used with dissolved phase water concentrations, total zinc concentrations in surface water were conservatively used to predict fish tissue concentrations.
- Measured surface water concentrations for the Project area were much higher than measured surface water concentrations in the region, which contributed to the high predicted fish tissue concentrations.
- The RQ values were based on a conservative oral exposure limit. Zinc is an essential metal and the oral exposure limit used in the HHRA falls within the higher end of the range of daily requirements for zinc to ensure that nutrient requirements are met.

Haematological Toxicants

Risk quotients for the haematological toxicant mixture exceeded 1.0 (i.e., 4.7 to 4.8) for the Aboriginal and community residents under all three assessment cases (Tables 3.6-11 and 3.6-12).

Interpretation of Results

Interpretation of these exceedances considered the following factors:

- the potential contribution from the Project to these predicted exceedances;
- the primary chemical contributor(s) to the haematological toxicant mixture;
- the primary exposure pathway contributing to these predicted exceedances; and
- the degree of conservatism incorporated in the assumed consumption patterns and exposure limits.

The Project is predicted to have little influence on the exceedances predicted for the haematological toxicants. There is no apparent increase between the predicted RQ values under the EAC and the Project Case for the Aboriginal and community residents. Risk estimates of 4.7 were predicted for the Aboriginal residents for the EAC and the Project Case, with a slight increase to 4.8 for the PDC. Risk estimates of 4.7 were predicted for community residents for all three assessment cases. Thus, the RQ values predicted under the Project Case were entirely attributable to the EAC predictions. The RQ values predicted for Aboriginal and community residents based on the Project alone were 0.000031 and 0.000022, respectively. These Project-related RQ values represent a 0.00046 to 0.00066% increase over the predicted EAC risk estimates, indicating that the Project is not predicted to appreciably increase the risk of adverse health effects associated with the long-term exposure to haematological toxicants in the region.

Assessment of the haematological toxicant mixture assumed an additive interaction between all haematological toxicants emitted from the Project. As such, the predicted chronic health risks associated with each of the individual haematological toxicants were summed.

The haematological toxicant mixture includes:

- aliphatic C_9-C_{16} group; and
- zinc.

The predicted risk for the haematological toxicant mixture is predominantly due to zinc, which represents 96% of the RQ values for the Aboriginal and community residents. Interpretation of the exceedances thus focused on the contribution of zinc to the risk estimates for the haematological toxicant mixture.

For reasons outlined in the zinc discussion, potential health risks associated with exposure to the haematological toxicant mixture are expected to be low.

Conclusions

Project emissions are predicted to have minimal effects on the potential health risks associated with long-term exposure to the haematological toxicant mixture in the region as there was no predicted change in the RQ values for the haematological mixture between the EAC and the Project Case.

Despite the predicted RQ values above 1.0, the weight-of-evidence indicates that there is low potential for haematological effects in the region as a result of chemical emissions. The weight-of-evidence is as follows:

- RQ values associated with zinc, which is the primary contributor to the mixture RQ values, are conservative estimates based on the assumptions made in the HHRA.
- The RQ values for zinc under the EAC were the result of assumed fish tissue concentrations. Predicted zinc concentrations in fish are likely overestimated based on a comparison to measured fish tissue concentrations in the region and the application of conservative assumptions.
- The compounding conservatism of the assessment of risks associated with each of the individual haematological toxicants likely overstates the actual cumulative risk of experiencing chemically induced haematological effects.

Neurotoxicants

Risk quotients for neurotoxicants exceeded 1.0 (i.e., 6.7 to 8.4) for the Aboriginal and community residents under all three assessment cases (Tables 3.6-11 and 3.6-12).

Interpretation of Results

Interpretation of these exceedances considered the following factors:

- the potential contribution from the Project to these predicted exceedances;
- the primary chemical contributor(s) to the neurotoxicants mixture;
- the primary exposure pathway contributing to these predicted exceedances; and

- the degree of conservatism incorporated in the assumed consumption patterns and exposure limits.

The Project is expected to have little influence on the exceedances predicted for the neurotoxicant mixture. There is no predicted change between the RQ values under the EAC and the Project Case for both the Aboriginal and community residents, indicating that the Project is not expected to appreciably increase the risk of adverse health effects associated with the long-term exposure to neurotoxicants in the region. The RQ value predicted for Aboriginal residents based on the Project alone is 0.00012. This RQ value represents a 0.0018% increase over the predicted EAC RQ. As such, the risk estimates predicted under the Project Case are entirely due to the existing conditions captured under the EAC. Similarly, there is no predicted change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are entirely due to the existing conditions captured under the EAC.

The RQ value predicted for community residents based on the Project alone is 0.000073. This RQ value represents a 0.000086% increase over the predicted EAC RQ. As such, the risk estimates predicted under the Project Case are entirely due to the existing conditions captured under the EAC. In addition, there is negligible change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are also entirely due to the existing conditions captured under the EAC.

Assessment of the neurotoxicants mixture assumed an additive interaction between all neurotoxicants emitted from the Project. As such, the predicted chronic health risks associated with each of the individual neurotoxicants were summed. The neurotoxicant mixture includes:

- aliphatic C_2-C_8 group;
- lead;
- manganese; and
- methyl mercury.

Much of the predicted risk for the neurotoxicants mixture is attributed to manganese and methyl mercury. Together, manganese and methyl mercury represent 99% of the predicted RQ values for the Aboriginal and community residents. Interpretation of the exceedances thus focused on the contribution of manganese and methyl mercury to the risk estimates for the neurotoxicants mixture.

The maximum RQ values predicted for manganese for the community resident are based on the exposure characteristics of a toddler, whereas, the most sensitive life stage identified for the community resident was the infant. The RQ values predicted for methyl mercury are based on the exposure characteristics of a toddler for both the Aboriginal and community residents. Combining the risk estimates for two distinct life stages likely overstates the risk to the overall lifestyle category, in this case, the community residents.

The primary exposure pathways contributing the EAC RQ values for manganese and methyl mercury are shown in Table 3.6-18 for each lifestyle category. Risks associated with manganese are primarily due to baseline concentrations in vegetation while risks associated with methyl mercury appear to be entirely due to baseline concentrations in fish.

Table 3.6-18 Contribution of Individual Exposure Pathways to Potential Risk Quotients for Manganese and Methyl Mercury

Exposure Pathway	Percent Contribution [%]			
	Aboriginal Resident		Community Resident	
	Manganese	Methyl Mercury	Manganese	Methyl Mercury
ingestion of soil (inadvertent)	0.3	0	0	0
ingestion of water	1.6	0	0	0
ingestion of leafy vegetation	22	0	98	0
ingestion of root vegetables	9	0	0.1	0
ingestion of fruit	55	0	2.0	0
ingestion of fish	0	100	0	100
ingestion of wild game	12	0	0	0

For reasons outlined in the manganese and methyl mercury discussions, potential health risks associated with exposure to the neurotoxicant mixture are expected to be low.

Conclusions

Project emissions are predicted to have a minimal effect on the potential health risks associated with long-term exposure to the neurotoxicant mixture in the region as there were no changes predicted in the RQ values for the neurotoxicant mixture between the EAC and the Project Case. Similarly, no changes were predicted for the EAC and the Project Case RQ values of the primary contributors (i.e., manganese and methyl mercury) to the mixture's risks.

Despite the predicted RQ values above 1.0, the weight-of-evidence indicates that there is low potential for neurotoxicological effects in the region as a result of chemical emissions. The weight-of-evidence is as follows:

- RQ values associated with manganese and methyl mercury, which are the primary contributors to the mixture RQ values, are conservative estimates based on the assumptions made in the HHRA.
- Most of the methyl mercury RQ values under the EAC were the result of predicted fish concentrations. Given that measured concentrations of mercury in fish collected in the area were much lower than the predicted methyl mercury concentrations used in the HHRA, the risk estimates associated with fish consumption are likely overstated.
- The compounding conservatism of the assessment of risks associated with each of the individual neurotoxicants likely overstates the actual cumulative risk of experiencing chemical-induced neurological effects.

Reproductive/Developmental Toxicants

Risk quotients for reproductive/developmental toxicants exceeded 1.0 (i.e., 6.0) for the Aboriginal and community residents under all three assessment cases (Tables 3-6-11 and 3.6-12).

Interpretation of Results

Interpretation of these exceedances considered the following factors:

- the potential contribution from the Project to these predicted exceedances;
- the primary chemical contributor(s) to the reproductive/developmental toxicants mixture;
- the primary exposure pathway contributing to these predicted exceedances; and
- the degree of conservatism incorporated in the assumed consumption patterns and exposure limits.

The Project is expected to have little influence on the exceedances predicted for the reproductive/developmental toxicants mixture. There is no predicted change between the RQ values under the EAC and the Project Case for both the Aboriginal and community residents. The RQ values predicted for Aboriginal and community residents based on the Project alone are 0.00012 and 0.0001, representing 0.002 and 0.0016% increases over the predicted EAC RQ respectively. Thus, the risk estimates for the Project Case appear to be entirely due to the existing conditions captured under the EAC. The Project is not expected to contribute to potential reproductive and/or developmental effects in the region. Similarly, there is no predicted change between the EAC and PDC, indicating that the risk estimates predicted under the PDC are entirely due to the existing conditions captured under the EAC.

Assessment of the reproductive/developmental toxicants mixture assumed an additive interaction between all reproductive and/or developmental toxicants emitted from the Project. As such, the predicted chronic health risks associated with each of the individual reproductive and/or developmental were summed. The reproductive/developmental toxicants mixture includes:

- lead;
- methyl mercury; and
- nickel.

Much of the predicted risk for the reproductive/developmental toxicants mixture is attributed to methyl mercury, which represents 98% of the predicted RQ values for the Aboriginal and community residents. Interpretation of the exceedances thus focused on the contribution of methyl mercury to the risk estimates for the reproductive/developmental toxicants mixture.

For reasons outlined in the methyl mercury discussion, potential health risks associated with exposure to the reproductive/developmental toxicant mixture are expected to be low.

Conclusions

Project emissions are predicted to have a minimal effect on the potential health risks associated with long-term exposure to the reproductive/developmental toxicants mixture in the region as there was no change predicted in the RQ values for the reproductive/developmental toxicants mixture between the EAC and the Project Case.

Despite the predicted RQ values above 1.0, the weight-of-evidence indicates that there is low potential for reproductive and/or developmental effects in the region as a result of chemical emissions. The weight-of-evidence is as follows:

- RQ values associated with methyl mercury, which is the primary contributor to the mixture RQ values, are conservative estimates based on the assumptions made in the HHRA.

- Most of the methyl mercury RQ values under the EAC were the result of predicted fish concentrations. Given that measured concentrations of mercury in fish collected from the area were much lower than the predicted methyl mercury concentrations used in the HHRA, the risk estimates associated with fish consumption are likely overstated.
- The compounding conservatism of the assessment of risks associated with each of the individual reproductive/developmental toxicants likely overstates the actual cumulative risk of experiencing chemical-induced reproductive and/or developmental effects.

3.6.3.2 Carcinogens

All life stages were considered when predicting cancer risks. Exposures to carcinogens were summed for each life stage over a person's entire lifespan. Arsenic and the carcinogenic PAH groups 1 to 3 were the only carcinogens to be assessed through multiple routes of exposure. The LCR values for the EAC and ILCR values for the Project and Future Emission Sources are presented in Tables 3.6-19 and 3.6-20.

The predicted ILCR values associated with the Project (i.e., Project Case minus EAC) and the Future Emission Sources (i.e., PDC minus EAC) were all less than 1:100,000, indicating that the incremental cancer risk is deemed to be "essentially negligible" according to Health Canada protocol (Health Canada 2004a).

Lifetime Cancer Risk (LCR) values greater than 1.0 were predicted for the Aboriginal and community residents in the EAC assessment of the following:

- arsenic;
- carcinogenic PAH group 1; and
- "stomach carcinogens" mixture.

The predicted LCR values that exceeded 1.0 are discussed below.

Table 3.6-19 Chronic Lifetime and Incremental Lifetime Cancer Risks per 100,000 From Multiple Pathways of Exposure – Aboriginal Residents

Chemicals of Potential Concern	Lifetime Cancer Risk(a)	Incremental Lifetime Cancer Risk(b)	
	Existing and Approved Case	Project Emission Sources (Project Case – EAC)	Future Emission Sources (PDC – EAC)
Arsenic	**4.3E+00**	3.4E-03	3.9E-03
Carcinogenic PAH group 1	**2.0E+00**	3.3E-02	5.4E-02
Carcinogenic PAH group 2	6.0E-04	2.1E-05	3.4E-05
Carcinogenic PAH group 3	6.3E-03	1.1E-04	1.8E-04
Mixtures(c)			
Stomach carcinogens	**2.0E+00**	3.4E-02	5.5E-02
Acceptable Incremental Lifetime Cancer Risk	*n/a*	*1*	*1*

(a) Lifetime cancer risks refer to the number of cancer cases that could potentially result from the estimated exposures to the carcinogenic COPCs among a population of 100,000 people. Since an acceptable cancer incidence rate has not been recommended for exposure to carcinogens associated with anything other than the Project and Future Emission Sources by any leading scientific or regulatory authority, interpretation of the significance of the LCR values determined for the EAC could be not based on comparison against a numerical “benchmark” of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(b) An ILCR equal to or less than 1.0 signifies an incremental lifetime cancer risk that is below the benchmark ILCR of one in 100,000 (i.e., within the generally accepted limit deemed to be protective of public health). Boldface values show an ILCR of greater than the de minimus risk level of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-12.

n/a = Not applicable

Table 3.6-20 Chronic Lifetime and Incremental Lifetime Cancer Risks per 100,000 From Multiple Pathways of Exposure – Community Residents

Chemicals of Potential Concern	Lifetime Cancer Risk(a)	Incremental Lifetime Cancer Risk(b)	
	Existing and Approved Case	Project Emission Sources (Project Case – EAC)	Future Emission Sources (PDC – EAC)
Arsenic	**1.6E+00**	2.8E-03	3.2E-03
Carcinogenic PAH group 1	**2.0E+00**	3.4E-02	5.5E-02
Carcinogenic PAH group 2	6.1E-04	1.5E-05	3.1E-05
Carcinogenic PAH group 3	6.3E-03	1.1E-04	1.8E-04
Mixtures(c)			
Stomach carcinogens	**2.0E+00**	3.4E-02	5.5E-02
Acceptable Incremental Lifetime Cancer Risk	*n/a*	*1*	*1*

(a) Lifetime cancer risks refer to the number of cancer cases that could potentially result from the estimated exposures to the carcinogenic COPCs among a population of 100,000 people. Since an acceptable cancer incidence rate has not been recommended for exposure to carcinogens associated with anything other than the Project and Future Emission Sources by any leading scientific or regulatory authority, interpretation of the significance of the LCR values determined for the EAC could be not based on comparison against a numerical “benchmark” of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(b) An ILCR equal to or less than 1.0 signifies an incremental lifetime cancer risk that is below the benchmark ILCR of one in 100,000 (i.e., within the generally accepted limit deemed to be protective of public health). Boldface values show an ILCR of greater than the de minimus risk level of one in 100,000. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) Individual constituents of the chemical mixtures are identified in Table 3.4-12.

n/a = Not applicable.

Arsenic

Due to recent concerns raised regarding the potential health risks associated with measured arsenic levels in the Oil Sands Region, AHW commissioned a study to investigate the potential lifetime cancer risks that could be presented to people living in the Oil Sands Region from arsenic exposure through consumption of wild game and other traditional food items (AHW 2007).

The study found that "baseline" lifetime cancer risks were estimated to range from 17 to 33 in 100,000. In addition, incremental lifetime cancer risks associated with planned industrial emissions were in the range of 1 to 2 in 100,000. The drinking water and fish consumption exposure pathways primarily contributed to the predicted exposures. Lesser contributions were reported for the consumption of root vegetables and game meat (AHW 2007). Finally, the study concluded that "the lifetime cancer risks that could potentially result from exposure to inorganic arsenic among indigenous people living in the Wood Buffalo region are dominated by already existing naturally occurring and anthropogenic sources of arsenic in the region, with very little incremental risk presented by the projected future anthropogenic activities" (AHW 2007).

In the current assessment, EAC LCR values of 4.3 and 1.6 were predicted for the Aboriginal and community residents, respectively. This indicates that lifetime exposure to background levels of carcinogens via multiple pathways could potentially contribute to 2 to 4 cases of cancer when calculated on a 100,000 person population basis. When expressed in terms of the actual number of permanent residents in the Wood Buffalo region (74,728; ACB 2006, Website), the number of cancer cases predicted to occur as a result of inorganic arsenic exposure would be between 1 and 3 cases.

A policy-based regulatory benchmark of an acceptable incremental lifetime cancer risk of 1:100,000 has been established. However, regulators have not recommended an acceptable cancer incidence rate (or LCR) for exposure to carcinogens associated with background or "baseline" conditions (e.g., EAC). Given that an acceptable "benchmark" cancer risk level for exposure to background levels of carcinogens is not available for comparison, the "acceptability" of this potential lifetime cancer risk from a public health perspective cannot be determined using a conventional approach.

Interpretation of the arsenic risks considered the following:

- the primary exposure pathway contributing to the predicted LCRs;

- the margins of safety incorporated into both the exposure and toxicity estimates by virtue of the conservative assumptions used in the HHRA; and
- the typical background exposures to arsenic for the general population in Canada or the United States and how these compare to the predicted arsenic exposures in the HHRA.

The primary exposure pathways contributing to arsenic exposure for the Aboriginal residents were drinking water (37%), the consumption of local wild game (14%) and the consumption of cattail root (46%). For the community residents, much of the arsenic exposure was attributable to drinking water (50%) and the consumption of local wild game (37%) and fish (8%).

Conservatism was introduced into virtually every step of the assessment, extending to both the exposure and toxicity assessment. The HHRA conservatively assumed:

- residents would be exposed to the 95 UCLM concentration of local environmental media, including soil, vegetation, wild game, water and fish every day over a 75-year period;
- 95 UCLM values in the environmental media were predicted using half of the method detection limit;
- predicted environmental media concentrations were based on 75 years of continuous Project emissions and associated chemical deposition despite the expected operational life of the Project (i.e., 34 years);
- 78% of total arsenic in vegetables or forage was assumed to be inorganic, as opposed to the 37% assumed by Health Canada in its estimation of total daily inorganic arsenic for Canadians (Schoof et al. 1999; CEPA 1993; Health Canada 1995);
- 25% of total arsenic in wild game was assumed to be inorganic, which appears to be conservative relative to the result of two total diet studies (Schoof et al. 1999; U.K. FSA 2004, Website);
- 2% of total arsenic in fish was assumed to be inorganic, which appears to be conservative relative to the result of two total diet studies (Schoof et al. 1999; U.K. FSA 2004, Website); and
- Aboriginal residents would obtain 100% of their food and water from local sources, while community residents would obtain 100% of their wild game and fish and 10% of their fruits and vegetables from local sources.

Estimated daily intakes of inorganic arsenic for the community and Aboriginal residents based on 95 UCLM environmental media concentrations ranged from 0.013 to 0.035 µg/kg bw/d. In comparison, the Canadian average daily arsenic intake for a typical adult is between 0.1 and 0.7 µg/kg bw/d (CEPA 1993). Average intake levels for Aboriginal and community residents described in the HHRA are less than those estimated for "average" Canadians. Although the estimated daily exposures to arsenic appear to be somewhat exaggerated, the EAC risk estimates for arsenic are largely due to the conservative nature of the Health Canada oral exposure limit of 0.006 µg/kg bw/d used in the HHRA (Health Canada 2004a).

Liver tumours are the critical chronic toxicological effect for arsenic (Health Canada 2006). The ACB (2005, Website) indicates that a total of 115 new cases of liver and intra-hepatic bile duct cancer per 100,000 (males and females combined) were diagnosed. Out of all Alberta cases of cancer in 2003 about 1% were of the liver and intra-hepatic bile ducts (115 out of 12,571). In theory, background exposure to arsenic could account for 1.6 to 4.3 of those cases per 100,000 people in the region. However, consideration must be given to the degree of conservatism incorporated into the exposure limit used for the assessment of arsenic.

As part of the AHW study, a comprehensive published literature review was completed that detailed the toxicity of arsenic, with emphasis on identifying and summarizing information respecting the cancer-causing potential of arsenic (AHW 2007). It is generally accepted that arsenic can act as a human carcinogen; however, considerable debate surrounds the carcinogenic potency of arsenic, especially at low-dose levels. Of particular relevance to the current HHRA, are the following items:

- Much of the evidence supporting an association between exposure to arsenic and elevated cancer rates originates from epidemiological studies of people living in southeast Asia and South America. In contrast, most studies completed in North America have shown no association between arsenic levels in drinking water and the occurrence of cancer.
- There is mounting evidence that the carcinogenicity of arsenic may represent a high-dose phenomenon only (i.e., consistent with a threshold-type response). Some evidence even suggests that low doses of arsenic may confer a protective effect against the occurrence of cancer (ATSDR 2005b, U.S. NRC 1999).
- The mechanism by which arsenic causes cancer is not well established. It is currently unclear whether arsenic acts directly via a genetically mediated mechanism, thereby qualifying arsenic as a "non-threshold"

> carcinogen, or through one or more non-genotoxic mechanisms, thereby qualifying arsenic as a "threshold" carcinogen. The difference in classification could have a considerable bearing on cancer risk estimates.

As such, use of the Health Canada RsD, which was derived based on the premise that arsenic acts as a "non-threshold" carcinogen, may overstate the carcinogenic potency of arsenic. Thus, cancer risk estimates calculated on the basis of this RsD may be exaggerated and should be interpreted with caution, and with full understanding of the conservatism incorporated into the exposure limit (Appendix 3-VII provides details on the Health Canada RsD).

Carcinogenic Polycyclic Aromatic Hydrocarbon Group 1

LCR values of 2.0 were predicted under the EAC for the Aboriginal and community residents. This indicates that lifetime exposure to background levels of carcinogens via multiple pathways could potentially contribute to two cases of cancer when calculated on a 100,000 person population basis. When expressed in terms of the actual number of permanent residents in the Wood Buffalo region (74,728; ACB 2006, Website), the number of cancer cases predicted to occur as a result of exposure to the carcinogenic PAH group 1 would be one case. Given that an acceptable "benchmark" cancer risk level for exposure to background levels of carcinogens is not available for comparison, the "acceptability" of this potential lifetime cancer risk from a public health perspective cannot be determined following a conventional approach.

Interpretation of the carcinogenic PAH group 1 risks considered the following:

- the primary exposure pathway contributing to the predicted LCRs;
- the margins of safety incorporated into the exposure estimates by virtue of the conservative assumptions used in the HHRA; and
- the typical background exposures to carcinogenic PAHs for the general population in North America or Europe and how these compare to the predicted carcinogenic PAH exposures in the HHRA.

The primary exposure pathway contributing to exposure to the carcinogenic PAH group 1 for the Aboriginal and community residents was the consumption of local wild game (99.7 and 99.6%, respectively).

The estimated daily intake of the carcinogenic PAH group 1 for the adult Aboriginal and community residents based on 95 UCLM environmental media concentrations was 0.26 µg/d. It is important to note that the method of cooking wild game could potentially result in a higher exposure. Regardless, the estimated daily exposure falls at the lower end of estimated daily intakes for total PAHs and at the higher end of the range of estimated daily intakes for benzo(a)pyrene and dibenz(a,h)anthracene (both constituents of the carcinogenic PAH group 1) predicted for the general population in North America and Europe. The estimated daily intake of the carcinogenic PAH group 1 for the adult Aboriginal and community residents adjusted for body weight was 0.0037 µg/kg bw/d, which falls within the range of background exposures provided by the RIVM (2001) of 0.0027 µg/kg bw/d and 0.24 µg/kg bw/d for benzo(a)pyrene and total PAHs, respectively. Estimated daily intakes to PAHs from food and/or all exposure pathways for the general populations in North America and Europe are provided in Table 3.6-21.

Table 3.6-21 Estimated Daily Intakes of Polycyclic Aromatic Hydrocarbons in North America and Europe

Estimated Intakes [µg/day]	Description[a][b]
Canada	
0.026 to 2.6	Estimated average daily intake of individual PAHs in food by Canadians. Individual PAHs evaluated include fluoranthene, benzo(k)fluoranthene, dibenz(a,i)pyrene, 9,10-dimethylbenzanthracene, benz(a)anthrancene, benzo(b)fluoranthene and dibenz(a,h)anthracene.
0.061 to 0.10	Estimated average daily intake of dibenz(a,h)anthracene in food by Canadians.
United States	
1 to 5	Intake of carcinogenic PAHs for an American adult male based on an average American diet.
6 to 9	Intake of carcinogenic PAHs for an American adult male consuming a diet with large meat content.
3	The median total exposure to carcinogenic PAHs for an American adult male when considering all pathways.
0.05	The U.S. EPA estimated a daily benzo(a)pyrene intake from food.
0.18	The daily median total ingested dose of benzo(a)pyrene based on a urinary biomarker study of 14 adult volunteers in New Jersey over 14 consecutive days.
1.6 to 16	Estimated daily oral PAH intakes (including 30% carcinogenic PAHs) from food *per capita* in the United States.
0.16 to 1.6	Estimated daily benzo(a)pyrene intake from food *per capita* in the United States.
Europe	
1.1 to 22.5	Estimated daily oral PAH intakes from food *per capita* in the Netherlands.
0.03 to 0.35	Estimated daily benzo(a)pyrene intake from food *per capita* in the Netherlands.
5 to 17	Mean daily dietary intake of total PAHs (17 compounds evaluated) for 18-year old males based on a Dutch market-basket survey.
0.12 to 0.29	Estimated daily benzo(a)pyrene intake from European total diets.
0.25, 0.17, 0.03	Estimated daily intake in the United Kingdom for benzo(a)pyrene, benzo(e)pyrene and dibenz(a,h)anthracene, respectively.

[a] Source: ATSDR (1995); IPCS (1998); OEHHA (1997, Website); WHO (1996, Website; 2000, Website; 2003).

[b] The carcinogenic PAH group 1 includes benzo(a)pyrene, benzo(e)pyrene, dibenz(a,h)anthracene and 1-nitropyrene.

Conservatism was introduced into virtually every step of the assessment, extending to both the exposure and toxicity assessment. The HHRA conservatively assumed:

- Residents would be exposed to the 95 UCLM concentration of local environmental media, including soil, vegetation, wild game, water and fish every day over a 75-year period.
- 95 UCLM values in the environmental media were predicted using half of the MDL.
- Predicted environmental media concentrations were based on 75 years of continuous Project emissions and associated chemical deposition despite the expected operational life of the Project (i.e., 34 years).
- Tissue concentrations from local wild game were based on the maximum predicted ground-level air concentrations of all discrete receptor locations, including the fence-line MPOI. It is unlikely that wild game would forage at one discrete location over their entire lifetime and be exposed to maximum concentrations predicted in air, soil, water and vegetation.
- Aboriginal residents would obtain 100% of their food and water from local sources, while community residents would obtain 100% of their wild game and fish and 10% of their fruits and vegetables from local sources.

Overall, cancer risk estimates may be exaggerated and should be interpreted with caution, and with full understanding of the conservatism incorporated into the assessment.

Stomach Carcinogens

LCR values of 2.0 for the stomach carcinogens mixture were predicted under the EAC for the Aboriginal and community residents. This indicates that lifetime exposure to background levels of stomach carcinogens via multiple pathways could potentially contribute two cases of cancer when calculated on a 100,000 person population basis. This translates to one potential case of stomach cancer when expressed in terms of the actual number of permanent residents in the Wood Buffalo region (74,728; ACB 2006, Website). Given that an acceptable “benchmark” cancer risk level for exposure to background levels of carcinogens is not available for comparison, the “acceptability” of this potential lifetime cancer risk from a public health perspective cannot be determined following a conventional approach.

Interpretation of the risks to the stomach carcinogens considered the following:

- the primary chemical contributor(s) to the stomach carcinogens mixture;
- the primary exposure pathway contributing to the predicted LCRs;
- the margins of safety incorporated into the exposure estimates by virtue of the conservative assumptions used in the HHRA; and
- the typical background exposures to carcinogenic PAHs for the general population in Canada or the United States and how these compare to the predicted carcinogenic PAH exposures in the HHRA.

Assessment of the mixture assumed an additive interaction between all stomach carcinogens emitted from the Project. As such, the predicted chronic health risks associated with each of the individual stomach carcinogens were summed. The stomach carcinogens mixture includes the carcinogenic PAH groups 1 to 3.

Much of the predicted risk for the stomach carcinogens mixture is attributed to carcinogenic PAH group 1, which represents 99.7% of the predicted risk for the Aboriginal and community residents. Interpretation of the exceedances thus focused on the contribution of the carcinogenic PAH group 1 to the risk estimates for the stomach carcinogens mixture.

The primary exposure pathway for the carcinogenic PAH group 1 was the consumption of local wild game for the Aboriginal and community residents (99.7 and 99.6%, respectively).

For reasons outlined in the carcinogenic PAH group 1 discussion, potential health risks associated with exposure to the stomach carcinogens are expected to be low.

Overall, cancer risk estimates for the stomach carcinogens are likely exaggerated and should be interpreted with caution, and with full understanding of the conservatism incorporated into the assessment.

3.6.3.3 Residual Impact Classification

Residual impacts for key question HHPDC-2 are classified in Table 3.6-22. Key question HHPDC-2 asked “What are the risks of adverse human health effects from long-term (chronic) exposure to air emissions and water releases from existing and approved developments, the Project and planned developments?”

The impact classification criteria (e.g., duration, frequency, geographic extent) are already incorporated into the risk estimates and therefore residual impacts are defined by the magnitude of effect as determined from risk estimates. Negligible magnitudes of effect (i.e., chronic multiple pathway) were predicted for most parameters assessed in the HHRA. Low magnitudes of effect was predicted for arsenic, carcinogenic PAH group 1, manganese, methyl mercury, zinc, haematological toxicants, neurotoxicants, reproductive/developmental toxicants and stomach carcinogens.

Table 3.6-22 Residual Impact Classification for Key Question HH-2

Parameter	Group at Risk	Magnitude of Effect
arsenic, carcinogenic PAH group 1, methyl mercury, zinc, haematological toxicants, neurotoxicants, reproductive/developmental toxicants, stomach carcinogens	Aboriginal and community residents	low
manganese	community residents	low
all other COPCs	none (parameters met guidelines)	negligible
all other mixtures	none (parameters met guidelines)	negligible

3.7 MONITORING

MEG will monitor Project emission sources as required by the Alberta *Environmental Protection and Enhancement Act* (EPEA) approval. In addition, MEG has applied to become a member of the following:

- Wood Buffalo Environmental Association (WBEA). The WBEA program includes strategies and plans for ambient air monitoring conducted in the region. These are reviewed on an ongoing basis by the WBEA to understand the need for program adjustments to assess the effects of new developments in the region.
- Cumulative Environmental Management Association (CEMA). The CEMA program is a forum for stakeholders to address cumulative effects of the regional development in northeastern Alberta. The program provides the forum to discuss and make consensus-based decisions on the development and application of environmental management tools, thresholds, guidelines and objectives.

3.8 CONCLUSIONS

Overall, the Project is not expected to appreciably increase the risk of adverse health effects in the region. For all COPCs, there are negligible changes between the predicted health risks under the EAC and the Project Case. Similarly, cumulative health risks associated with the Project in combination with other planned projects and activities are not expected to result in measurable health effects in the region. The changes between the predicted health risks under the EAC and PDC are generally low or negligible.

3.8.1 Short-Term Effects

Inhalation health risks associated with the Project air emissions on a short-term basis were evaluated by comparing maximum predicted acute or short-term air concentrations with health-based regulatory guidelines considered protective of the most sensitive individuals. With one exception, predicted acute RQ values did not exceed 1.0 for any of the individual COPCs and chemical mixtures under any of the three assessment cases (i.e., EAC, Project Case and PDC). This demonstrates that in most cases, predicted COPC air concentrations were less than their health-based guidelines and that the additive interactions of the COPCs are not predicted to result in health-related impacts. Therefore, health risks for these COPCs and mixtures are considered negligible.

The one possible exception involves the potential exposure of persons to maximum SO_2 concentrations along the Project fence-line. Although the predicted RQ values for the Project Case and PDC exceeded 1.0 for transient persons, the weight-of-evidence suggests that there is a low potential for health effects to occur as a result of SO_2 emissions.

3.8.2 Long-Term Effects

3.8.2.1 Inhalation

Inhalation health risks associated with the Project air emissions on a long-term basis were evaluated by comparing maximum predicted chronic or long-term air concentrations with health-based regulatory guidelines considered protective of the most sensitive individuals.

Predicted chronic RQ values for non-carcinogens did not exceed 1.0 for any of the individual COPCs and chemical mixtures under any of the three assessment cases (i.e., EAC, Project Case and PDC). This demonstrates that predicted COPC air concentrations were less than their health-based guidelines and the additive interactions of the COPCs are not predicted to result in health-related impacts. Therefore, health risks for these COPCs and mixtures are considered negligible.

For the carcinogens, maximum predicted ILCR values associated with the Project (i.e., Project Case minus EAC) and Future Emission Sources in the area (i.e., PDC minus EAC) are all less than 1 in 100,000 indicating that the incremental cancer risk from the Project and planned development is deemed to be “essentially negligible” (Health Canada 2004a).

3.8.2.2 Multiple Pathways

Health risks associated with multiple pathways of exposure (i.e., inhalation, ingestion and dermal contact) were predicted by comparing exposure estimates with health-based oral guidelines.

In most cases, the RQ values for the non-carcinogenic COPCs and mixtures did not exceed 1.0 under the three assessment cases. The exceptions include manganese, methyl mercury, zinc, the haematological toxicants mixture, the neurotoxicants mixture and the reproductive/developmental toxicants mixture. For each of these COPCs and mixtures, the potential health risks were dominated by the predicted risks for the EAC.

- Given the negligible change in health risks between the EAC and the Project Case, the Project emissions are predicted to have minimal impact on the potential health risks associated with long-term exposure in the region.

For all carcinogenic COPCs, the predicted ILCR values associated with the Project (i.e., Project Case minus EAC) and the Future Emission Sources (i.e., PDC minus EAC) were all less than 1 in 100,000, indicating that the incremental cancer risk is deemed to be “essentially negligible” according to Health Canada protocol (Health Canada 2004a). The LCR values greater than 1.0 were predicted for the Aboriginal and community residents in the EAC assessment for arsenic, carcinogenic PAH group 1 and the stomach carcinogens mixture. However, regulators have not recommended an acceptable cancer incidence rate (or LCR) for exposure to carcinogens associated with background or “baseline” conditions. Given that an acceptable “benchmark” cancer risk level for exposure to background levels of carcinogens is not available for comparison, the “acceptability” of the potential lifetime cancer risk from a public health perspective cannot be determined following a conventional approach.

Overall, health risks in the region associated with multiple pathways of exposure to the COPCs and mixtures are considered negligible, or low in the case of arsenic, carcinogenic PAH group 1, manganese, methyl mercury, zinc, haematological toxicants, neurotoxicants, reproductive/developmental toxicants and stomach carcinogens.

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4 AIR EMISSIONS EFFECTS ASSESSMENT

4.1 INTRODUCTION

MEG Energy Corp. (MEG) is a Calgary-based, privately held energy company focused on the development and recovery of bitumen, shallow gas reserves and the generation of power in northeast Alberta. MEG's Christina Lake Regional Project (CLRP) consists of 80 sections of oil sands leases within the Regional Municipality of Wood Buffalo (RMWB), approximately 15 km southeast of Secondary Highway 881 and 20 km northeast of Conklin.

MEG currently has approval to construct and operate the first two phases of the CLRP over 23 sections of land. In addition, MEG is developing a facility expansion (Phase 2B) to increase the production capacity of the Central Plant to 60,000 barrels per day (bpd). The Phase 2B plant will be located immediately adjacent to the existing Phase 1 and 2 processing facilities.

MEG is now proposing a further expansion of the CLRP to fully develop its Christina Lake oil sands leases. The Christina Lake Regional Project – Phase 3 (the Project) is an expansion of the current CLRP development area and will use Steam Assisted Gravity Drainage (SAGD) bitumen recovery technology. The Project will consist of two additional processing facilities (Plants 3A and 3B), 138 SAGD multi-well pads and associated steam generating equipment. Plant 3A will be located in the southeast corner of the lease (Sections 20 and 29-76-4 W4M) and Plant 3B will be located in the northwest end of the lease (Sections 32 and 33-77-6 W4M).

Construction of the Project is proposed to occur in two phases. Phase 3A is anticipated to begin construction in 2010, with initial steam injection in 2012. Phase 3B is anticipated to begin construction in 2012, with initial steam injection in 2014. The operational life of each plant is expected to be 25 years. Total production from the two new plants will produce an incremental 150,000 bpd of bitumen (approximately 23,800 cubic metres per day). It is anticipated that reclamation of the Project will be complete by 2044.

This section provides details on the assessment of Air Emission Effects (AEE) on ecological receptors, including aquatic and terrestrial resources. Section 4.2 summarizes the assessment approach including methods for aquatic and terrestrial resources. Section 4.3 describes the Existing and Approved Case (EAC), while Sections 4.5 and 4.6 provide the assessments of the Project Case and Planned Development Case (PDC), respectively. Conclusions of the assessment are presented in Section 4.7.

Appendix 3-XII includes:

- a review of the potential effects of air emissions on ecological receptors;
- a review of past and current information related to AEE;
- a complete description of the assessment methods used for aquatic resources and terrestrial resources including soils, terrestrial vegetation and wetlands, and wildlife and wildlife habitat; and
- background information for the assessment of the effects of acid deposition on aquatic systems and biota.

The effects of the Project on human health are presented in Section 3.

4.2 ASSESSMENT APPROACH

4.2.1 Component Description

The objective of this assessment is to evaluate the potential effects of air emissions on ecological receptors for the EAC, Project Case and PDC. Air emissions effects considered in this assessment are acid deposition resulting from emissions of oxides of nitrogen (NO_X) and sulphur dioxide (SO_2), eutrophication effects from emissions of nitrogen compounds, and direct effects of ground-level concentrations of SO_2, nitrogen dioxide (NO_2) and ozone (O_3) on vegetation. Air emissions and the prediction of deposition and ground-level concentrations within the study areas for these cases are described in Sections 1.6, 1.8 and 1.9, respectively.

4.2.2 Assessment Cases

Three assessment cases (EAC, Project Case and PDC) have been identified for evaluating possible air quality-related effects associated with the Project. Potential effects of air emissions on ecological receptors were assessed based on the following three assessment cases:

- The EAC includes an assessment of the cumulative effects from the existing and approved industrial emission sources within the region. Although the sources considered in EAC have been approved, it will be several years before the activities in the region increase from the existing levels of emissions to those used in the EAC.
- The Project Case provides a cumulative assessment of the emissions from the Project in combination with EAC emissions in the region.

- The PDC includes a cumulative assessment of the existing and approved projects in the region, the Project and other publicly disclosed projects in the region. Since the PDC includes planned projects, none of which have received approval to operate and some of which have yet to apply for approval, the information used in the PDC is speculative and based on the best information available as of October 2007.

4.2.3 Terms of Reference

This assessment was completed to meet the relevant TOR (AENV 2008) for the Project (Table 4.2-1) which state the following:

Table 4.2-1 Air Emissions Effects on Ecological Receptors Terms of Reference Concordance Table

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
4.1.5 Modeling	[A] For each model used in the in the assessment scenarios, provide: (a) a justification for the model used. Air quality modeling should be conducted in accordance with the latest edition of the Air Quality Modeling Guidelines published by Alberta Environment; (b) a documentation of the assumptions used to obtain the modeling predictions; and (c) a discussion of the limitations of the models used and how these limitations were addressed, including sources of error and relative accuracy.	Volume 3, Appendix 3-XII, Section 4 Air Emissions Assessment Methods
4.2 Climate, Air Quality and Noise		
4.2.2 Impact Assessment	[A] Identify components of the Project that will affect local and regional air quality, and	[A] Volume 3, Appendix 3-II, Section 3.1.1 MEG Project Emissions in the Project Case
	(f) describe air quality impacts resulting from the Project, and their implications for other environmental resources, including habitat diversity and quantity, vegetation resources, water quality and soil conservation.	(f) Volume 3, Section 4
4.5 Surface Water Quality		
4.5.2 Impact Assessment	(d) assess the potential Project related and cumulative impacts of acidifying and other air emissions on surface water quality; and	(d) Volume 3 Sections 4.4 Linkage Analysis, Section 4.7 Conclusions
4.8 Wildlife		
4.8.2 Impact Assessment	i) potential effects on wildlife as a result of changes to air, water, including both acute and chronic effects on animal health, and	(b) i) Volume 3, Section 4.5.2.3 Wildlife and Wildlife Habitat Effects Analysis and Section 4.6.2.3 Wildlife and Wildlife Habitat Analysis, 4.7.2 Terrestrial Resources

Table 4.2-1 Air Emissions Effects on Ecological Receptors Terms of Reference Concordance Table (continued)

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
4.10 Terrain and Soils		
4.10.2 Impact Assessment	(d) identify the potential acidification impact on soils and discuss the significance of predicted impacts by acidifying emissions resulting from the Project;	(d) Volume 3, Section 4 Air Emission Effects on Ecological Receptors; Volume 3, Section 4.4 Mitigation and Monitoring; Volume 3, Section 4.5 Existing and Approved Conditions; Volume 3, Section 4.6 Project Case; Volume 3, Section 4.7 Planned Development Case

4.2.4 Key Issues and Key Questions

One of the key issues for the project is the effect of air emissions on ecological receptors. Key questions have been developed to address this key issue. The following Key questions consider the potential effects of the Project under the Project Case (i.e., the Project plus existing and approved developments) and the Planned Development Case (PDC: Project Case plus planned developments).

AEEPC-1: What effects could air emissions from existing and approved developments and the Project have on waterbodies and the aquatic resources therein?

AEEPC-2: What effects could air emissions from existing and approved developments and the Project have on soils?

AEEPC-3: What effects could air emissions from existing and approved developments and the Project have on terrestrial vegetation and wetlands?

AEEPC-4: What effects could air emissions from existing and approved developments and the Project have on wildlife and wildlife habitat?

AEEPDC-1: What effects could air emissions from existing and approved developments, the Project and planned developments have on waterbodies and the aquatic resources therein?

AEEPDC-2: What effects could air emissions from existing and approved developments, the Project and planned developments have on soils?

AEEPDC-3: What effects could air emissions from existing and approved developments, the Project and planned developments have on terrestrial vegetation and wetlands?

AEEPDC-4: What effects could air emissions from existing and approved developments, the Project and planned developments have on wildlife habitat?

4.2.5 Temporal Considerations

The air quality assessment and the associated assessment of effects on ecological receptors consider worst-case conditions through the life of the Project in terms of emissions. The proposed schedule for development of the major components of the Project is summarized in Volume 1, Section 1.2.7. Construction of Phase 3A is scheduled to begin in 2010 with initial steam injection in 2012. Phase 3B is expected to begin construction in Q4 2012 with initial steam injection in 2014. The operational life of each plant is expected to be 25 years. It is anticipated that reclamation of the Project will be complete by 2044.

The Air Emissions Effects on Ecological Receptors assessment considers reasonable worst case expected emissions through the life of the Project as described in the Air Quality Assessment (Section 1.2.4).

4.2.6 Spatial Considerations

The terrestrial resources portion of the assessment used the Terrestrial Resources Regional Study Area (RSA) (Volume 5, Section 2.5). Typically, the terrestrial air study area for oil sands EIAs has been based on the farthest measurable extent of emission species potentially affecting terrestrial ecological receptors for the PDC. However, in this assessment, these areas are so small that a study was not warranted. Sections 4.3.2, 4.5.2 and 4.7.2 describe the extent of deposition and ground-level concentrations of emission species relating to terrestrial resources.

The aquatic resources assessment focuses on the effects of air emissions from the Project and regional developments on lakes in the air quality modelling domain, as described in Section 1.2.5, and streams located within the Aquatics Local Study Area (LSA) as described in Volume 4, Section 2.2.2. The effects of acid deposition on surface waters over the entire modelling domain were considered to maximize the spatial coverage of the assessment and to consider all lakes included in similar assessments conducted recently. This area includes the entire Oil Sands Region and extends into western Saskatchewan.

4.2.7 Calculation of Potential Acid Inputs for the Assessment

Potential Acid Input (PAI, in units of keq/ha/yr) has historically been defined in oil sands assessments as the sum of SO_2 and NO_x deposition minus base cation deposition, as estimated by air dispersion modelling. This calculation represents potential acid inputs entering the terrestrial ecosystem from all sources but does not take into account retention of deposited nitrogen (N) in terrestrial ecosystems and is therefore referred to as the "gross PAI". Nitrogen absorbed in terrestrial ecosystems does not contribute to the acidification of soils or surface waters. This assessment uses a more refined approach to the estimation of PAI for both aquatic and terrestrial resources, by incorporating the retention of N by terrestrial ecosystems and also includes a quantitative assessment of changes in snowmelt pH based on gross PAI.

Terrestrial Resources

The terrestrial air emission effects assessment is based on "soil net PAI", which takes into account uptake of N in terrestrial ecosystems. The calculation of soil net PAI includes all SO_2 deposition, all NO_x deposition above 10 kg N/ha/yr and 25% of NO_x deposition below the first 10 kg N/ha/yr. The representation of N retention was recommended by the NO_x/SO_2 Working Group (NSMWG 2007) based on the conclusions of a recent report that estimated that the forest ecosystems in the Athabasca Oil Sands Region can absorb N deposition of 8 to 24 kg N/ha/yr for 100 years (Callesen and Gundersen 2005). The lower value of 8 kg N/ha/yr is near the lower limit of the range of thresholds reported for nitrogen leaching (Callesen and Gundersen 2005; Sullivan 2000). Inclusion of 25% of the deposited nitrogen under 10 kg N/ha/yr was recommended to address uncertainty.

Background SO_2, NO_x and base cation deposition were estimated based on results of the Alberta Environment (AENV) Regional Lagrangian Acid Deposition (RELAD) model (Cheng 2001; Appendix 3-II). The incremental increase in SO_2 and NO_x above background for each assessment case was estimated using air dispersion modelling described in Volume 3, Section 1.3.2. Predicted SO_2 and NO_x deposition rates for each assessment case are provided in Sections 1.6, 1.8 and 1.9.

Aquatic Resources – Lakes

The assessment for lakes is based on "lake net PAI", which also takes into account nitrogen uptake in terrestrial ecosystems using the approach described above for the calculation of soil net PAI. The difference between soil net PAI and lake net PAI is in the representation of background acid inputs and base cation deposition. Background lake net PAI was calibrated based on measured sulphate and nitrate concentrations in lakes rather than from the AENV RELAD modelling to provide a more accurate estimation of acid inputs entering lakes under background conditions after uptake in terrestrial ecosystems. Values from the AENV RELAD modelling represent deposition prior to uptake in terrestrial ecosystems.

The neutralizing effect of base cation deposition was not included in lake net PAI because base cation inputs from all sources are already accounted for in the critical load calculated for each lake. The critical load calculation, including the contribution of base cations from all sources is provided in Appendix 3-XII, Section 4.2.2.2.

Aquatic Resources – Snowmelt pH

The predicted pH of snowmelt was used as a component of the assessment of changes in episodic acidification of streams. The historical definition of PAI, referred to as gross PAI, was used in the calculation of snowmelt pH, to provide a conservative estimate of pH prior to infiltration to soils. Gross PAI does not include nitrogen uptake in terrestrial ecosystems, but does include the neutralizing effect of base cation deposition.

4.2.8 Aquatic Resources Assessment Methods

Industrial activities have the potential to affect aquatic ecosystems through the release of air emissions that may result in acid deposition. Emissions of NO_X and SO_2 are the main contributors to acid deposition. The direct effect of acid deposition is a reduction of pH in acid-sensitive lakes and streams that in turn may alter other aspects of water chemistry (e.g., the solubility of aluminum). Acidification of surface waters due to air emissions and the resulting biological effects have been widely documented in both North America and Northern Europe (e.g., Jeffries 1997; Henriksen et al. 1992).

This section contains a summary of the approach used to evaluate the effects of acid deposition on surface waters. A complete description of methods is provided in Appendix 3-XII.

This assessment evaluates the potential effects of air emissions from the Project and regional developments on water quality and aquatic biota in the air quality modelling domain (Section 1.2). Air emission scenarios are described in Sections 1.6, 1.8 and 1.9. Effects considered in this section include potential changes to the chemistry and biota of lakes, ponds and streams. For the purposes of this assessment, all waterbodies (i.e., lakes and ponds) are referred to as “lakes”. Wetlands were combined with terrestrial systems in this assessment (Section 4.2.9).

The sensitivity of surface waters to acid deposition was evaluated based on alkalinity or Acid Neutralizing Capacity (ANC). These terms are now used interchangeably and refer to the capacity of water to neutralize strong inorganic acids (Wetzel 2001). The term “alkalinity” is typically used when neutralizing capacity is estimated using titration, whereas “ANC” is used when it is calculated.

Alkalinity is often expressed in units of mg/L as calcium carbonate ($CaCO_3$), assuming that alkalinity results only from calcium carbonate and bicarbonate, which may or may not be applicable to a given lake. Therefore, the clearest expression of alkalinity is in terms of µeq/L or meq/L. For comparative purposes, alkalinity of 1 mg/L as $CaCO_3$ = 20 µeq/L, or 50 mg/L as $CaCO_3$ = 1 meq/L.

Assessment Methods for Lakes

The potential for acidification of standing waters was evaluated by comparing lake-specific critical loads with the corresponding predicted lake net PAI for each assessment case for all lakes in the air quality modelling domain. A lake net PAI value above the critical load was considered an indication that the lake’s buffering capacity may be exceeded; with a subsequent drop in pH below a specified threshold value (pH of 6 was used in this assessment because numerous studies have shown that a pH of 6 is sufficient to maintain a healthy aquatic ecosystem and to protect fish and other aquatic organisms, see Appendix 3-XII, Section 4.2.2.2).

Critical loads were calculated for 416 regional lakes (Figure 4.2-1). The critical load has been defined in general terms as “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” (Nilson and Grennfelt 1988). For evaluating the effects of acid deposition, the critical load can be thought of as an estimate of the amount of acidic deposition below which no significant harmful effects occur to a specified component of a lake’s ecosystem (e.g., a valued fish species) (Appendix 3-XII, Section 4.2.2.2, Sullivan 2000). Critical loads were calculated using net runoff estimates for each lake catchment and available water quality data for each lake. The detailed methods for the critical load calculation, data sources and comparisons to previously calculated critical loads are provided in Appendix 3-XII. Exact lake locations, identifiers and chemistry information are provided in Appendix 3-XII, Table 11.

The assessment approach was based on the application of critical loads according to the Steady-State Water Chemistry (SSWC) model (Henriksen and Posch 2001). Adjustments were made to the critical load calculation to account for the effects of organic acids that may affect the ANC of lakes with high dissolved organic carbon content, using the method described by the Regional Aquatics Monitoring Program (RAMP 2005).

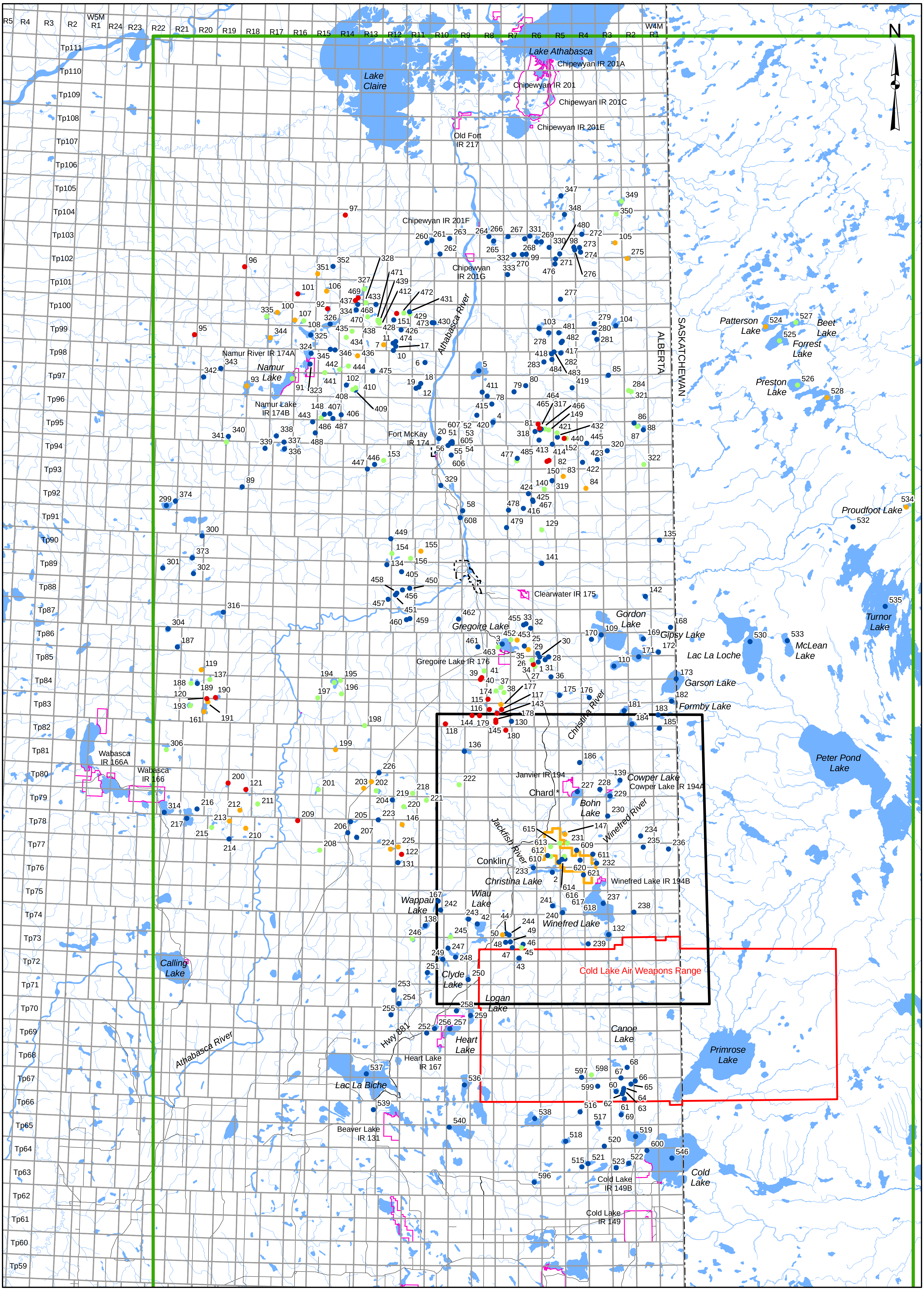
The general procedure for evaluating the potential for lake acidification included the following steps:

- lakes within the air quality modelling domain were selected for assessment, based on availability of data for calculating critical loads;
- background lake net PAI was calibrated based on sulphate and nitrate concentrations in the lakes;
- lake net PAI was calculated as the sum of background lake net PAI and incremental lake net PAI above background derived from air dispersion modelling;
- critical loads were calculated for each lake based on historical base cation concentrations and available hydrology data;
- critical loads were compared with lake net PAI; and
- effects were classified based on effect description criteria.

Assessment Methods for Streams

The potential for episodic stream acidification (i.e., spring acid pulses) was evaluated using a weight-of-evidence approach that included qualitative and quantitative methods taking into account:

- changes in SO_2 and NO_X emission rates in the region and the predicted contribution of the Project;
- changes in snowmelt pH in the region and the predicted contribution of the Project;
- the degree of acid sensitivity estimated from water chemistry, watershed characteristics and climate; and
- results of an analysis of data collected by AENV during spring acid pulse monitoring in the Oil Sands Region (WRS 2002).



50 0 50

SCALE 1:1,500,000 KILOMETRES

LEGEND

- 🟩 AIR QUALITY MODELLING DOMAIN
- ☐ AIR REGIONAL STUDY AREA
- 🟧 MEG LEASE BOUNDARY
- ☐ INDIAN RESERVE
- 🟥 AIR WEAPONS RANGE
- 🟦 OPEN WATER
- — RIVER OR STREAM
- — ROADWAY

LAKE SENSITIVITY BASED ON ALKALINITY (mg/L)

- ● HIGH
- ● MODERATE
- ● LOW
- ● LEAST

NOTE

The air quality domain extends approximately 40 km further south than shown, however no additional lakes are included.
*Also known as the Hamlet of Janvier

REFERENCE

Alberta digital data obtained from Geomatics Canada (August 2001), AltaLIS Ltd. (September 2004), Veritas DGC Inc. (July 2004), Alberta Pacific Ltd. (April 2004), LANDSAT 5 TM Imagery (2005), used under license.
Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: UTM Zone 12 Datum: NAD 83

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

REGIONAL LAKES CONSIDERED IN THE AIR EMISSIONS EFFECTS ASSESSMENT

MEG ENERGY CORP.

PROJECT No. 07-1346-0009.9180			SCALE AS SHOWN	REV. 0
DESIGN	LD	20 Nov. 2007	FIGURE: 4.2-1	
GIS	TN	21 Feb. 2008		
CHECK	LD	27 Mar. 2008		
REVIEW	IGG	28 Mar. 2008		

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4.2.9 Terrestrial Resources Assessment Methods

Industrial activities also have the potential to affect terrestrial systems through release of air emissions that can affect terrestrial resources through direct or indirect pathways. For example, air emissions can directly affect vegetation when concentrations or deposition rates are high enough to cause foliar necrosis or chlorosis. Acidifying emissions can cause a reduction in soil base saturation, increase the availability of phytotoxic metals such as aluminum and affect soil fertility (Robarge and Johnson 1992), thereby directly affecting soils and indirectly affecting vegetation.

Direct effects are evaluated through the calculation of ground-level concentrations of SO_2, NO_2 and O_3. Oxides of nitrogen (NO_X) emissions occur primarily as nitric oxide (NO) and are converted to NO_2 through reactions with ambient ozone, thus direct effects are assessed via NO_2. Acidic deposition for terrestrial resources is evaluated through comparison of soil net PAI to critical loads. As the majority of effects are related to chronic exposure, the annual average values for air emissions are considered for soil net PAI. For air emissions such as SO_2 and NO_2, maximum hourly, daily and annual concentrations are reviewed.

This section contains a summary of the approach typically used to evaluate the effects of acid deposition on terrestrial resources. A complete description of methods is provided in Appendix 3-XII. Only some of the steps included in the typical approach could be applied in this assessment due to the limited extent of deposition and ground-level concentrations of emissions species and the very small contribution of the Project to regional emissions.

Air deposition results showed that there were no PAI soil exceedences in the terrestrial RSA under any of the three Cases. Additionally, other emissions species (SO_2, NO_2, nitrogen deposition) only exceeded for certain averaging periods over a limited area (far less than 1% of the terrestrial RSA). Therefore, the potential for effects to occur is negligible and analysis is limited to documenting the change in area of those measurable emissions.

4.2.9.1 Soils Assessment Methods

The soil acidification assessment was consistent with the Cumulative Environmental Management Association (CEMA) publication "Recommendations for the Acid Deposition Management Framework for the Oil Sands Region of North-Eastern Alberta" (CEMA 2004).

The 50-year, fixed-case soil critical loads were selected for this assessment and exceedances were calculated for non-developed areas only. All areas classified as disturbances in the terrestrial assessment (Volume 5) including urban centres, industrial facilities, roads and pipelines were excluded from the assessment. The 50-year mid-case soil critical loads were calculated as per the CEMA (2004) Framework document and are presented in Appendix 3-XII. The 50-year, fixed-case soil critical loads are considered to be a more appropriate metric to evaluate in the assessment as this endpoint is indicative of actual potential effects unlike the mid-case endpoint which is only indicative of progression half-way to the actual threshold (fixed case). The procedure was as follows:

- Fixed-case 50-year soil series specific critical loads were selected for detailed assessment analysis (Appendix 3-XII, Table 10).
- The soil net PAI contours from air dispersion modelling were calculated for the EAC, Project Case and PDC.
- The soil net PAI contours for the EAC, Project Case and PDC were overlain on the soil maps and a Geographic Information System (GIS) was used to designate where soil critical loads were exceeded. The areas considered for the assessment were those within the soil net PAI 0.17 keq/ha/yr isopleth for the PDC.
- If a lake critical load was exceeded, the soils in the watershed of the lake were assumed to have critical loads exceeded as per methods described in CEMA (2004).
- The area and percentage of soils above critical loads for each township was outlined on a map and presented in tables. Areas were calculated as percentages of the soil net PAI 0.17 keq/ha/yr isopleth for the PDC case as per the CEMA (2004) framework.
- The net change in areas affected between the EAC and Project Case was calculated.
- Effects description criteria ratings were made based on the total areas affected.

Soil critical loads have been determined by relating specific soil chemistry changes (i.e., base cation to aluminum ratio, pH) to soil net PAI, as described in Appendix 3-XII.

4.2.9.2 Terrestrial Vegetation and Wetlands Assessment Methods

Air emissions from oil sands operations that may affect vegetation health are as follows:

- SO_2 and NO_2, which can affect vegetation directly through deposition or high concentrations;
- nitrogen deposition, which can result in nutrient enrichment;

- NO_X and SO_2, which can indirectly affect vegetation through deposition on soil and water, measured as soil net PAI; and
- ozone.

Sulphur Dioxide and Nitrogen Dioxide

The sensitivity of vegetation to direct SO_2 impacts is fairly well documented (Malhotra and Blauel 1980; Torn et al. 1987; Legge et al. 1988; Bruteig 1992). The importance of NO_X as an air emission that may affect vegetation and wetlands resources has only been recognized relatively recently. Air emissions, including NO_2 have been shown to affect lichens, which are considered the most sensitive plant groups to air emissions (Appendix 3-XII, Section 2.3.2.2). Studies of the corticolous (tree dwelling) lichens, *Evernia mesomorpha* and *Usnea spp*. in the Oil Sands Region found that concentrations of air emissions and trace elements showed a trend of decreasing deposition concentration and corresponding effects on lichens with increasing distance from oil sands developments (Berryman et al. 2004; Conor Pacific 1997). The Conor Pacific (1997) study did not detect substantial or consistent differences in the general health of tree species within jack pine stands that occur within low and high depositional areas.

For analysis the procedure is:

- isopleths of SO_2 and NO_2, representing the Alberta Ambient Air Quality Objectives (AAAQO), are overlain with the regional vegetation map using GIS;
- developed areas (i.e., disturbances, industrial and urban areas) are removed from the analysis, as there is assumed to be no effect to vegetation in a developed area; and
- the maximum concentrations outside of developed areas and the percent change in areal extent of the exceedance are reported for each assessment case.

Effects are based on percent change, calculated by subtracting the EAC percent area from the Project Case area and dividing the result by the EAC total vegetated area, then multiplying by 100.

Sulphur Dioxide

Annual concentrations are appropriate for detailed assessments of chronic effects deemed to be the most injurious to vegetation (World Health Organization (WHO) 2000). In Alberta, only vegetation within an area exceeding 30 $\mu g/m^3$ of SO_2 is considered potentially affected under the annual AAAQO.

The WHO has proposed an annual SO_2 deposition guideline of 30 µg/m^3/yr (WHO 1994). This value was also adopted by the AAAQO. The AAAQO guideline includes a margin for safety. However, an extension of this criterion is required to display some of the inherent variability of vegetation types to SO_2 and to provide a more conservative estimate of possible effects.

In the second release of the *Air Quality Guidelines for Europe* (WHO 2000), the WHO suggests an annual critical load of 20 µg/m^3 for forests and natural vegetation. This lower value was proposed due to the high sensitivity of conifers during needle elongation and the longevity of these species. Lichens lack a protective cuticle and are considered to be the most sensitive species to the effects of SO_2. Reports reviewed by the WHO have shown damage to the most sensitive lichens at SO_2 emission levels of 30 µg/m^3/yr. The WHO proposes an annual critical load of 10 µg/m^3 for the protection of lichens.

To demonstrate some of the variability of SO_2 effects to vegetation, annual SO_2 emissions were modelled as follows:

- vegetation mapped as having a high sensitivity (i.e., lichens and some mosses) may be affected at critical loads of more than 10 µg/m^3/yr;
- vegetation mapped as having moderate and high sensitivities may be affected at critical loads of more than 20 µg/m^3/yr; and
- all vegetation (low, moderate and high sensitivities) may be affected at critical loads of more than 30 µg/m^3/yr (annual SO_2 AAAQO).

This approach is similar to the model that the Clean Air Strategic Alliance (CASA) developed for soil critical load levels of PAI (CASA 1999). The vegetated areas within these deposition rates are reported in hectares, percent change and are calculated by subtracting the EAC area from the Project Case area and dividing the result by the EAC total vegetated area, then multiplying by 100.

Nitrogen Deposition

Although increases in oxides of nitrogen could lead to increased acidification, nitrogen can also be taken up and used by plants, leading to nitrogen eutrophication. Studies of plant species native to Alberta indicate that, at low concentrations NO_X may be beneficial to plants. This "fertilizer effect" of NO_X will likely be differentially beneficial depending on moss species and microhabitat. For example, acidophilic *Sphagnum* species, especially when found in oligotrophic conditions, showed increased growth with artificial acid input (Bayley et al. 1987; Rochefort and Vitt 1988). As such, acidification may cause shifts in species composition, abundance and biodiversity.

Shifts in bryophyte communities may have effects on peatlands (Rochefort and Vitt 1988). Nitrogen additions could lead to negative changes in species composition. Moreover, a shift from oligotrophic to eutrophic environments may reduce plant habitat for species that are better adapted to oligotrophic conditions (i.e., rare plants; Rochefort and Vitt 1988).

Nitrogen emissions from oil sands activities may contribute to anthropogenic nutrient loading of the surrounding environment. Nitrogen deposition is derived from all gaseous species of elemental N and combines dry (gas or particles) and wet (dissolved ions) deposition. Net primary production values of rusty peat moss found in the Oil Sands Region suggest that a critical load of 0.25 keq/ha/yr of nitrogen is an appropriate marker of change to growth in Oil Sands Region bogs (Vitt et al. 2002).

Critical loads of 0.25 keq N/ha/yr are measured as the point where vegetation has the potential to respond to anthropogenic sources of nitrogen and 2.0 keq N/ha/yr gives a conservative estimate of the point where there is the potential of a negative impact to net primary production. The poor fen/bog regional vegetation class has the highest potential for effect due to nitrogen deposition in the terrestrial RSA. Therefore, the area of the poor fen/bog regional vegetation class within the isopleths was calculated using GIS. For each assessment case, the poor fen/bog regional vegetation class areas and percentage area affected are reported.

Acidification

Acidification is indicated using soil net PAI, which takes into account deposition of SO_2 and NO_X emissions, as well as other relevant factors. The methods for the assessment of effects to soils from acidifying emissions are outlined above. To measure indirect effects to vegetation, soil polygons with critical load exceedances were overlain on the regional vegetation map to delineate vegetation classes exceeding critical loads in the study area. The vegetated area potentially affected by acidification will differ from the soils area as areas without vegetation, such as cleared areas, are removed from the reported area. The percent change is calculated by subtracting the EAC percent area from the Project Case percent area and dividing the result by the EAC total vegetated area, then multiplying by 100.

Ozone

Ozone exerts a phytotoxic effect on vegetation only if a sufficient amount reaches sensitive sites in the leaf. At present, an appropriate conceptual model for predicting changes in ground-level ozone in the region is not available. Therefore, the effects of ozone were assessed qualitatively based on emissions of ozone precursor chemicals (i.e., NO_x and Volatile Organic Compounds [VOCs]). Processes affecting ozone formation and methods for estimating ground-level ozone concentrations are described in Section 1.8.5.1.

4.2.9.3 Wildlife and Wildlife Habitat Assessment Methods

In addition to direct effects (e.g., through inhalation), air emissions can impact wildlife health indirectly via potential effects to wildlife habitat and through ingested soil and vegetation. Both pathways are discussed in the Screening Level Wildlife Risk Assessment (Appendix 3-VI). Lichens are of high food value to caribou and are sensitive to air emissions (Appendix 3-XII, Section 2.3). Lichens, therefore, are the best indicator of potential effects of air emissions on wildlife habitat. Wildlife habitat potentially affected is determined as a subset of the vegetation potentially affected. Specifically measured are those cover types with high lichen food value. For ground-level concentrations of SO_2, NO_x and soil net PAI, the amount of sensitive wildlife habitat above the critical loads was reported and the percent change assessed.

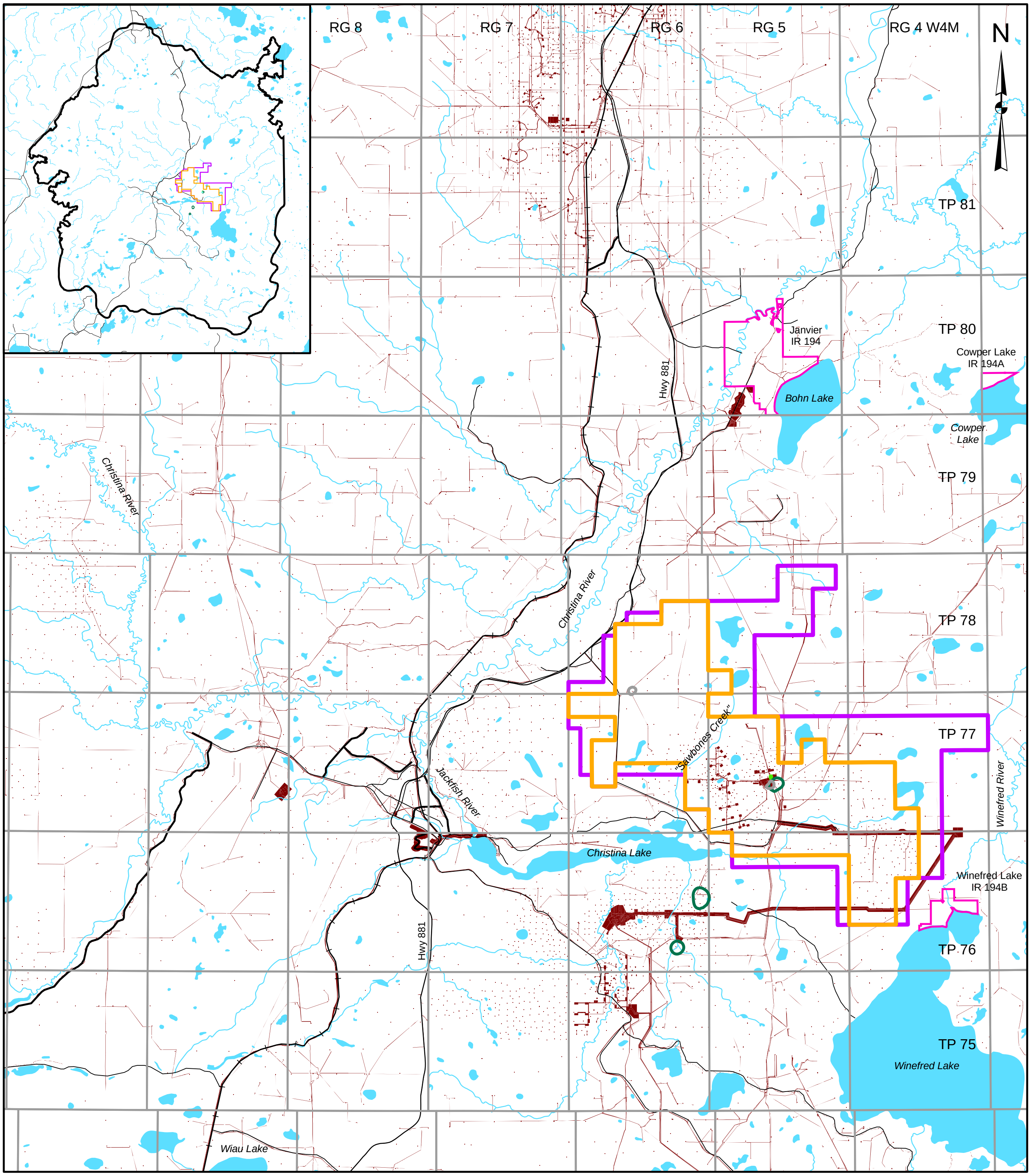
4.3 EXISTING AND APPROVED CASE

The EAC air quality assessment presents a cumulative evaluation of atmospheric releases from all existing and approved activities in the region, including oil sands operations, other industrial operations, transportation and community activities. EAC air quality predictions of regional SO_2, NO_x and soil net PAI are presented in Section 1.6.

The following sections present the assessment of air emissions effects from existing and approved developments on aquatic and terrestrial resources in the air quality modelling domain.

4.3.1 Aquatic Resources

Of the 416 lakes assessed, background lake net PAI values (estimated from historical water quality data) were above the corresponding critical loads for 18 lakes. All of the lakes where acid input is predicted to exceed critical loads under the EAC are outside the Air Quality RSA and are over 60 km away from the Project. Lake net PAI values for the EAC were above the critical loads for three additional lakes (Table 4.3-1). Measurements of pH for the lakes that exceed critical loads under background conditions were all below or marginally above six, which indicates that they are naturally acidified. Critical loads for these lakes are low or negative and exceeded background conditions, which is consistent with the observation that the lakes are naturally acidified.



10 0 10

SCALE 1:400,000 KILOMETRES

LEGEND

- ▭ TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- ▭ TERRESTRIAL RESOURCES LOCAL STUDY AREA
- ▭ MEG LEASE BOUNDARY
- ▭ INDIAN RESERVE
- ■ OPEN WATER
- — RIVER OR STREAM
- — ROADWAY
- —+— RAILWAY
- ▭ NITROGEN DEPOSITION (0.25 N keq/ha/yr)
- ▭ SOIL NET PAI ISOPLETH (0.17 keq/ha/yr)
- ▭ SO$_2$ HOURLY ISOPLETH (450 ug/m^3)

DISTURBED

- ■ EXISTING AND APPROVED DISTURBANCE
- — EXISTING AND APPROVED LINEAR DISTURBANCE

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

REFERENCE

Alberta digital data obtained from Geomatics Canada (August 2001), AltaLIS Ltd. (September 2004), Veritas DGC Inc. (July 2004), Alberta Pacific Ltd. (April 2004), LANDSAT 5 TM Imagery (2005), used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.

Projection: UTM Zone 12 Datum: NAD 83

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

ISOPLETHS IN THE TERRESTRIAL
REGIONAL STUDY AREA -
EXISTING AND APPROVED CASE

MEG ENERGY CORP.

PROJECT No. 07-1346-0009.9160			SCALE AS SHOWN REV. 1
DESIGN	AA	12 Nov. 2007	FIGURE: 4.3-1
GIS	TN	21 Feb. 2008	
CHECK	LD	26 Mar. 2008	
REVIEW	IGG	27 Mar. 2008	

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Nitrogen deposition rates for all lakes with critical load exceedances were well below the 8 kg N/ha/yr threshold. The area with deposition above 8 kg N/ha/yr, where nitrogen leeching leading to episodic acidification is possible, is more than 100 km away from the Project and outside the Air Quality RSA. Predicted lake net PAI values and nitrogen deposition rates for the 416 lakes included in the assessment are presented in Appendix 3-XII, Table 13.

A discussion of qualitative information related to stream sensitivity, including the results of the Western Resource Solutions (WRS 2002) study is provided in Appendix 3-XII, Section 5.1.2. The analysis indicates that streams in the area surrounding the Project are unlikely to be sensitive to acidification. The lowest stream alkalinity value (520 µeq/L) was measured in Unnamed Watercourse 1-04 (Appendix 4-IV, Figure 2) just to the southwest of the Project area and is more than twice the threshold value of 200 µeq/L, below which a stream is designated acid sensitive.

Table 4.3-1 Acid Input and Nitrogen Deposition Rates for the 21 Lakes With Critical Load Exceedances – Existing and Approved Case

Lake Identifier[a]	Lake Name/Original Identifier	Distance [km][b]	Direction[b]	pH	Critical Load of Acidity [keq/ha/yr]	Lake Net PAI [keq/ha/yr]		Nitrogen Deposition [kg/ha/yr]	
						Background[c]	EAC	AENV Background[d]	EAC
145	28[e], 28 (290)[f]	64	NNW	5.9	0.016	0.019	0.081	1.2	2.0
178	30[e]	65	NNW	5.2	-0.095	0.020	0.082	1.2	2.0
143	25[e], 25 (287)[f]	67	NNW	5.2	-0.054	0.030	0.095	1.2	2.0
117	26[e], A26[f]	68	NNW	5.6	0.009	0.032	0.100	1.2	2.0
179	31[e]	70	NNW	5.6	-0.060	0.061	0.119	1.2	1.9
116	24[e], A24[f]	70	NNW	4.7	-0.103	0.027	0.092	1.2	2.0
144	27[e], 27 (289)[f]	72	NW	6.5	0.033	0.015	0.070	1.2	1.9
115	21[e], A21[f]	74	NNW	5.0	-0.068	0.133	0.204	1.2	2.0
118	29[e], A29[f]	76	NW	5.8	-0.005	0.018	0.061	1.2	1.7
34	UNL1[g]	82	N	6.1	0.044	0.047	0.219	1.2	2.4
39	L10[g]	83	NNW	5.8	0.019	0.084	0.174	1.2	2.2
40	L11[g]	84	NNW	6.0	0.084	0.133	0.224	1.2	2.2
121	59[e], A59[f]	137	WNW	5.2	0.023	0.043	0.062	1.3	1.5
83	L7[h],[f]	159	N	6.4	0.187	0.114	0.233	1.1	2.5
150	P27[i],[f]	165	N	5.2	-0.019	0.027	0.159	1.1	2.8
82	170[e], 14[j], L4[h], A170 (L4)[f]	165	N	6.0	0.069	0.119	0.250	1.1	2.8
464	PM1[i]	179	N	4.2	-0.273	0.039	0.200	1.1	3.7
81	L1[h],[f]	181	N	6.3	0.183	0.076	0.226	1.1	3.7
469	PT2[i]	249	NNW	5.0	0.231	0.385	0.410	1.0	1.3
96	28[j], L28[h],[f]	280	NNW	5.2	-0.01	0.04	0.05	1.1	1.2
97	Clayton	283	NNW	4.3	-0.08	0.01	0.03	1.0	1.2

[a] Identifier used on map showing lake locations.

[b] Distance and direction relative to the Project.

[c] Estimated background lake net PAI based on measured nitrate and sulphate concentrations in lakes (Appendix 3-XII, Section 5.2).

[d] Estimated nitrogen deposition rates from the AENV RELAD modelling (Cheng 2001).

[e] Identifier used by previous EIAs; refer to Appendix 3-XII, Section 5.3.

[f] Identifier used by RAMP (2005).

[g] Identifier used by Saffran and Trew (1996).

[h] Identifier used by WRS (2004) for a survey of 34 lakes conducted by Alberta-Pacific Forest Industries in 1999.

[i] Identifier used by WRS (2004) for one hundred ponds sampled within the Oil Sands Region during September 2000.

[j] Identifier used by Erickson (1987).

Note: Acid deposition rates above the critical load are shaded.

4.3.2 Terrestrial Resources

For the EAC, the isopleths used for the assessment are scattered and localized in the Terrestrial RSA (Figure 4.3-1). These isopleths are discontinuous and represent a very localized and small area directly associated with other in-situ projects. Within the 1,538,591 ha terrestrial RSA, the soil net PAI 0.17 isopleths for the EAC case extend over 195 ha of vegetation and 259 ha in total area (including disturbances), which is less than 1% of the terrestrial RSA (Table 4.3-2). Within this area, there are no exceedances of soil critical loads for the EAC.

Table 4.3-2 Maximum Extent of Emission Isopleths in the Regional Study Area – Existing and Approved Case

Emission Species Isopleth	Spatial Extent Over Vegetated Areas [ha]	Spatial Extent Total [ha]
PAI - net soil (0.17 keq/ha/yr)(a)	195	259
SO_2 - annual (10 µg/m^3)(b)	0	0
SO_2 - hourly (450 µg/m^3)(c)	0	1
NO_2 - hourly (400 µg/m^3)(c)	0	0
Nitrogen Deposition – annual (0.25 N keq/ha/yr)(d)	13	40

(a) CEMA (2004).
(b) WHO (2000).
(c) AAAQO Objectives.
(d) Vitt et al. (2002).

4.4 LINKAGE ANALYSIS

Figure 4.4-1 provides the linkage diagrams for the assessment of air emissions effects on ecological receptors.

4.4.1.1 Key Question AEEPC-1 Linkage Analysis

AEEPC-1: What effects could air emissions from existing and approved developments and the Project have on waterbodies and the aquatic resources therein?

There are some acid-sensitive lakes in this area that could be affected by increased acid deposition. Reduced pH and associated chemical changes can cause lethal or sublethal toxic effects to fish and other aquatic life. Increased acid deposition also has the potential to contribute to episodic acidification in streams.

The Project will result in a marginal increase in acidifying emissions and a corresponding increase in acid deposition in the Oil Sands Region. The linkage between emissions and effects on regional waterbodies and aquatic resources is considered to be valid (Figure 4.4-1).

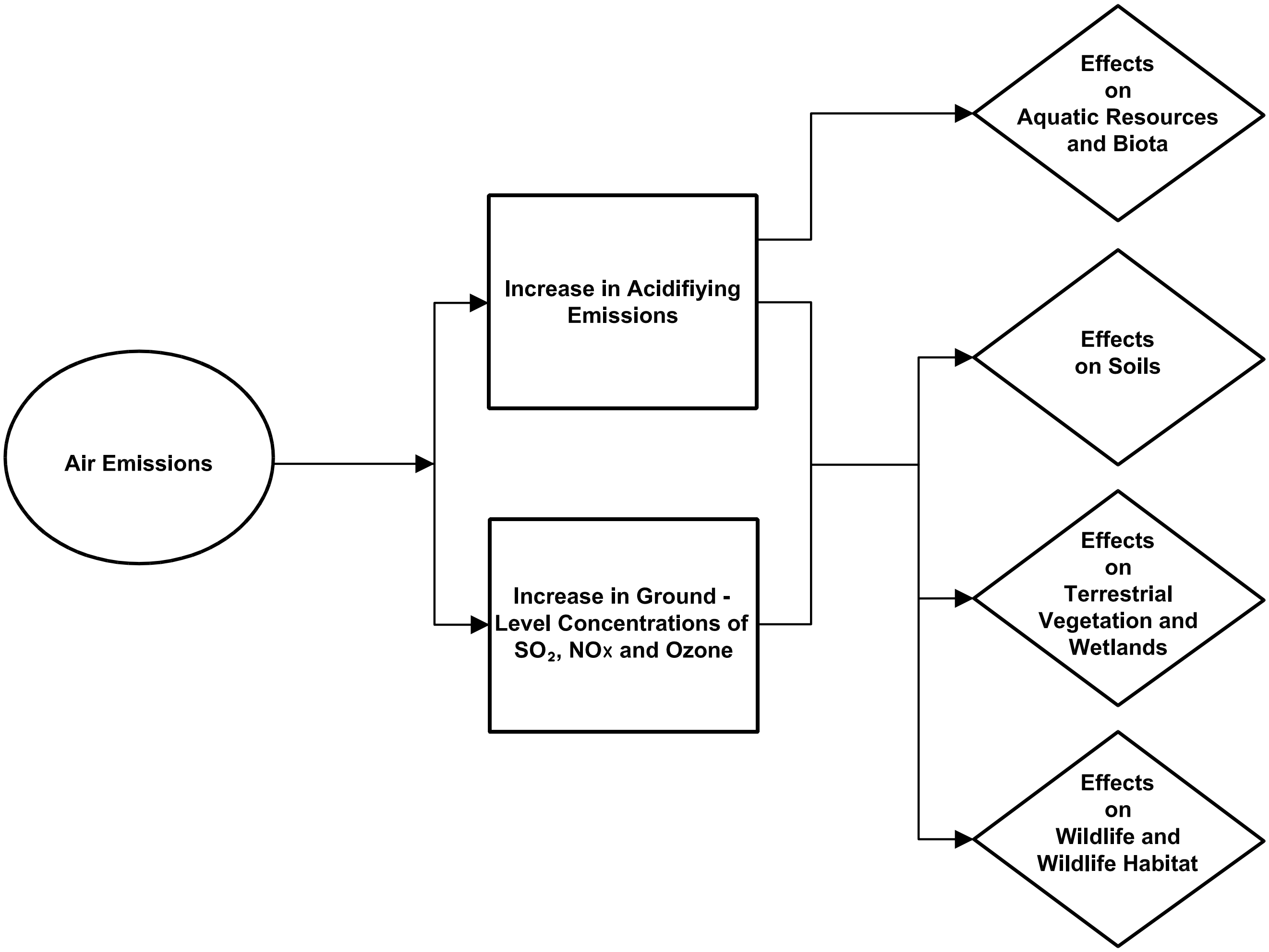
4.4.1.2 Key Question AEEPC-2 Linkage Analysis

AEEPC-2: What effects could air emissions from existing and approved developments and the Project have on soils?

This key question examines the potential effects of acidifying air emissions for the Project Case on soils within the terrestrial RSA.

The potential effects of acidifying emissions on sensitive ecosystems have been described in terms of critical loads, which are defined as "the highest load that will not cause chemical changes leading to long-term effects on the most sensitive ecosystem according to our present knowledge" (Bull 1991). An exceedance of the critical load suggests a potential excess of acidity compared to alkalinity in the soil. This increases the risk of soil acidification that may ultimately affect long-term forest growth (DeVries et al. 1994). Short-term exceedances of soil critical loads will not necessarily result in measurable effects on forest ecosystems, but the risk of impacts increases with time of exposure (Maynard 1996).

Air modelling information (Section 1.8) suggests acid deposition will exceed the critical loads in some areas. Therefore, there is a valid linkage between air quality and soils (Figure 4.4-1).



PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

LINKAGE DIAGRAM FOR AIR EMISSION EFFECTS ON ECOLOGICAL RECEPTORS

MEG ENERGY CORP.

PROJECT	07.1346.0009.8200	
DESIGN	LD	18/12/07
CADD	TY	21/02/08
CHECK	TR	28/03/08
REVIEW	IGG	28/03/08

FILE No. Linkage

SCALE AS SHOWN REV. 0

FIGURE: 4.4-1

L:\2007\1346 Oil Sands\07-1346-0009-MEG EXPANSION\8200\8220\Fig 4.4-1 Linkage Air Emission Effects-Eco-Recpts.dwg Mar 31, 2008 - 11:29am

4.4.1.3 Key Question AEEPC-3 Linkage Analysis

AEEPC-3: What effects could air emissions from existing and approved developments and the Project have on terrestrial vegetation and wetlands?

Key question AEEPC-3 examines the potential effects of acidifying air emissions for the Project Case on terrestrial vegetation and wetlands within the terrestrial RSA.

Sulphur dioxide (SO_2) emissions within the Air Quality RSA will increase marginally (less than 5%) due to the Project. Therefore, this linkage is valid for terrestrial vegetation and wetlands.

Nitrogen dioxide (NO_2) emissions within the Air Quality RSA will increase marginally (less than 5%) due to the Project. Therefore, this linkage is valid for terrestrial vegetation and wetlands.

Nitrogen deposition maximum values and aerial extent may increase as a result of the Project. Therefore, this linkage is valid for terrestrial vegetation and wetlands.

Acidifying emissions will increase as a result of the Project. However, no critical load exceedances were predicted for soils; therefore, this linkage is considered to be invalid for terrestrial vegetation and wetlands.

Increases in the anthropogenic (man-made) emissions of NO_X and VOCs in the region could result in limited increases in the peak 1-hour ozone concentrations, as discussed in Section 1.8.5. Therefore, this linkage is considered to be valid.

4.4.1.4 Key Question AEEPC-4 Linkage Analysis

AEEPC-4: What effects could air emissions from existing and approved developments and the Project have on wildlife and wildlife habitat?

This key question examines the potential effects of acidifying air emissions for the Project Case on wildlife and wildlife habitat within the terrestrial RSA. Regional caribou habitat (lichen) is used as it is considered the most susceptible to regional air emissions (Appendix 3-XII) Lichen is a major source of food for caribou in northern Alberta. High-quality habitat for caribou has a high lichen cover and was assumed to include the following four regional vegetation classes:

- coniferous – jack pine;

- mixedwood – jack pine-aspen;
- coniferous – jack pine-black spruce; and
- treed bog/poor fen.

Sulphur dioxide (SO_2) emissions from the Project will alter the regional maximum ambient concentrations and the areal extent of WHO guideline exceedances for the protection of lichens in the Project area (Section 1.8). Therefore, this linkage is considered to be valid.

Nitrogen dioxide (NO_2) emissions from the Project will alter the maximum concentration values and areal extent in the Project area (Section 1.8). Therefore, this linkage is considered to be valid.

No soil critical loads exceedances were predicted within the terrestrial RSA. Therefore, the linkage between soil acidification and effects on wildlife habitat is considered to be invalid.

4.5 PROJECT CASE

The Project Case assessment included a cumulative evaluation of air emissions from the Project, in combination with the emissions from existing and approved developments in the region. Project Case air quality predictions of regional SO_2, NO_x and soil net PAI are presented in Section 1.8. The developments used in this case are listed in Volume 2, Section 5.

The following sections present the assessment of effects of Project Case air emissions on aquatic and terrestrial resources.

4.5.1 Aquatic Resources

This section assesses the effects of increased acid deposition on acid sensitive lakes and streams in the areas.

4.5.1.1 Effects Analysis

Lake Acidification

Comparisons of critical loads with predicted lake net PAI values indicate that acid deposition from Project emissions will not result in additional exceedances of critical loads for any of the lakes included in the analysis (Table 4.5-1). For the lakes where acid input rates were above critical loads under the EAC, all had increases in lake net PAI of 0.6% or less relative to the EAC. Therefore, emissions of acidifying substances from the Project are predicted to have a negligible potential to affect water quality in these lakes.

Episodic Stream Acidification

Streams in the area surrounding the Project are unlikely to be sensitive to acidification (Appendix 3-XII, Section 5.1.2). The lowest stream alkalinity value (520 µeq/L) was measured in Unnamed Watercourse 1-04 (Appendix 4-IV, Figure 2) just to the southwest of the Project area and is more than twice the threshold value of 200 µeq/L, below which a stream is designated acid sensitive.

Project-related emissions are not predicted to affect the frequency and severity of episodic stream acidification. The Project is predicted to result in a 2% increase in NO_X emissions and a 0.46% increase in regional SO_2 emissions in the Air Quality RSA (Section 1.8-3, Table 1.8-4).

Nitrogen deposition is not predicted to exceed the threshold of 8 kg N/ha/yr, where nitrogen leeching leading to episodic acidification is possible. Therefore, deposited nitrogen is not expected to contribute to acidification.

The predicted maximum depression in snowmelt pH due to emissions from the Project is 0.11 pH units below EAC values (Appendix 3-XII, Section 5.5). The changes in emissions and snowmelt pH are too small to result in a measurable change in episodic acidification in streams and effects are predicted to be negligible.

Table 4.5-1 Acid Input and Nitrogen Deposition Rates for the 21 Lakes With Critical Load Exceedances – Project Case

Lake Identifier(a)	Lake Name/ Original Identifier	Location in Regional Study Area	Distance [km](b)	Direction(b)	pH	Critical Load of Acidity [keq/ha/yr]	Lake Net PAI [keq/ha/yr]				Nitrogen Deposition [kg/ha/yr]		
							Background(c)	EAC	Project Case	% Increase from EAC	AENV Background(d)	EAC	Project Case
145	28(e), 28 (290)(f)		64	NNW	5.9	0.016	0.019	0.081	0.081	0.6	1.2	2.0	2.0
178	30(e)		65	NNW	5.2	-0.095	0.020	0.082	0.082	0.5	1.2	2.0	2.0
143	25(e), 25 (287)(f)		67	NNW	5.2	-0.054	0.030	0.095	0.096	0.4	1.2	2.0	2.0
117	26(e), A26(f)		68	NNW	5.6	0.009	0.032	0.100	0.101	0.4	1.2	2.0	2.0
179	31(e)		70	NNW	5.6	-0.060	0.061	0.119	0.119	0.3	1.2	1.9	1.9
116	24(e), A24(f)		70	NNW	4.7	-0.103	0.027	0.092	0.092	0.4	1.2	2.0	2.0
144	27(e), 27 (289)(f)		72	NW	6.5	0.033	0.015	0.070	0.070	0.5	1.2	1.9	1.9
115	21(e), A21(f)		74	NNW	5.0	-0.068	0.133	0.204	0.204	0.2	1.2	2.0	2.0
118	29(e), A29(f)		76	NW	5.8	-0.005	0.018	0.061	0.061	0.6	1.2	1.7	1.7
34	UNL1(g)		82	N	6.1	0.044	0.047	0.219	0.219	0.2	1.2	2.4	2.4
39	L10(g)		83	NNW	5.8	0.019	0.084	0.174	0.175	0.2	1.2	2.2	2.2
40	L11(g)		84	NNW	6.0	0.084	0.133	0.224	0.225	0.2	1.2	2.2	2.2
121	59(e), A59(f)		137	WNW	5.2	0.023	0.043	0.062	0.062	0.4	1.3	1.5	1.5
83	L7(h),(f)		159	N	6.4	0.187	0.114	0.233	0.234	<0.1	1.1	2.5	2.5
150	P27(i),(f)		165	N	5.2	-0.019	0.027	0.159	0.159	<0.1	1.1	2.8	2.8
82	170(e), 14(j), L4(h), A170 (L4)(f)		165	N	6.0	0.069	0.119	0.250	0.250	<0.1	1.1	2.8	2.8
464	PM1(i)		179	N	4.2	-0.273	0.039	0.200	0.200	<0.1	1.1	3.7	3.7
81	L1(h),(f)		181	N	6.3	0.183	0.076	0.226	0.226	<0.1	1.1	3.7	3.7
469	PT2(i)		249	NNW	5.0	0.231	0.385	0.410	0.410	<0.1	1.0	1.3	1.3
96	28(j), L28(h),(f)		280	NNW	5.2	-0.01	0.04	0.05	0.054	<0.1	1.1	1.2	1.2
97	Clayton		283	NNW	4.3	-0.08	0.01	0.03	0.025	0.1	1.0	1.2	1.2

(a) Identifier used on map showing lake locations.

(b) Distance and direction relative to the Project.

(c) Estimated background acid input based on measured nitrate and sulphate concentrations in lakes (Appendix 3-XII, Section 5.2).

(d) Estimated nitrogen deposition rates from the AENV RELAD modelling (Cheng 2001).

(e) Identifier used by previous EIAs; refer to Appendix 3-XII, Section 5.3.

(f) Identifier used by RAMP (2005).

(g) Identifier used by Saffran and Trew (1996).

(h) Identifier used by WRS (2004) for a survey of 34 lakes conducted by Alberta-Pacific Forest Industries in 1999.

(i) Identifier used by WRS (2004) for one hundred ponds sampled within the Oil Sands Region during September 2000.

(j) Identifier used by Erickson (1987).

Note: Acid deposition rates above the critical load are shaded.

Percentage changes were calculated based on data with more than three decimals and does not support direct comparison of the rounded lake net PAI values provided in this table.

4.5.1.2 Effects Description Criteria

The effects of air emissions from the Project on local and regional surface waters are classified in Table 4.5-2.

Table 4.5-2 Effects Description Criteria for Air Emissions Effects on Regional Waterbodies – Project Case

Effect and Waterbody	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Acidification of local and regional lakes	negative	negligible (0)	regional (+1)	long-term (+2)	high (+2)	reversible (-3)	negligible (+2)
Episodic acidification of local and regional streams	negative	negligible (0)	regional (+1)	long-term (+2)	high (+2)	reversible (-3)	negligible (+2)

Note: Numerical scores for the ranking of environmental consequence is explained in Volume 2, Section 1.4.9.

The magnitude of the effects from emissions of acidifying substances on local and regional lakes is negligible. The effects are negative in direction and regional in geographic extent. Duration is classified as long-term, corresponding to the life of the Project. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The environmental consequence of the predicted effects is negligible.

The magnitude of the effects from emissions of acidifying substances on local and regional streams is negligible. The effects are negative in direction and regional in geographic extent. Effect duration is classified as long-term, corresponding to the life of the Project. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The environmental consequence of the predicted effects is negligible.

4.5.1.3 Certainty and Prediction Confidence

The assessment is subject to a moderate degree of uncertainty. This uncertainty has been addressed by using a conservative approach in making predictions, coupled with a high degree of certainty that the effects of Project emissions will not be greater than predicted. Sources of uncertainty include the following:

- Air quality modelling of acid deposition is subject to uncertainty, as described in Appendix 3-XII.

- The application of critical loads to Alberta lakes is still being developed and is subject to refinement. Adjustments to the calculation methods used herein may be necessary in the future based on results of ongoing research.
- Some of the critical loads were calculated based on limited water chemistry data.

The analysis of air emissions effects is conservative in the protective sense because of the conservative approach used to model acid deposition (i.e., simultaneous emissions at the fully approved rates from all developments). Therefore, there is a high degree of certainty that the effects of the Project emissions will not be greater than predicted.

Sensitivity analysis of the critical load calculation was undertaken as a component of several previous oil sands EIAs (Imperial Oil 2005; MEG 2005; Shell 2005; Suncor 2005). Varying the key terms used in the calculation of critical loads resulted in changes that were generally proportional to the introduced variation. The exception was the acid neutralizing capacity threshold (ANC_{lim}), where relatively large changes resulted in smaller changes in the critical load. Varying base cation concentrations and ANC_{lim} resulted in a progressively greater sensitivity at the lower end of the critical load scale, as critical loads dropped below 0.5 keq H^+/ha/yr. This finding underlines the importance of using reliable lake water chemistry data for calculating critical loads, especially for highly sensitive lakes.

Although some critical loads were calculated based on limited water chemistry data, and the sensitivity analysis indicates that critical loads are sensitive to variation in the data, several lines of evidence indicate that the analysis is robust. Data for 416 lakes were compiled from several sources, as described in Appendix 3-XII. Many of the data sources include sampling programs specifically aimed at characterizing potentially acid sensitive lakes, with an emphasis on generating reliable data for parameters related to acid-sensitivity. The Regional Aquatics Monitoring Program (RAMP) includes 50 acid-sensitive lakes in northeastern Alberta. Thirty-one of the lakes have five or six years of sampling and the other 19 lakes have three or fewer years of data. Therefore, the results of the assessment for the 416 lakes, particularly the 50 lakes intensively sampled by RAMP, conservatively represent potential effects for all lakes in the region.

4.5.1.4 Monitoring

Fifty lakes in the Oil Sands Region, including 13 of the 21 lakes with predicted acid input rates in excess of critical loads under the EAC and Project Case, are monitored annually by RAMP. Monitoring data are evaluated annually to detect early indicators of acidification and statistically or environmentally significant trends in lake chemistry. If trends are detected, required action under the NSMWG (2007) framework would be determined by the Alberta Government. No trends related to air emissions effects have been observed to date (Appendix 3-XII, Section 3).

4.5.2 Terrestrial Resources

This section assesses the potential effects of acidifying emissions on soils, terrestrial vegetation and wetlands for the EAC and Project Case. Air emissions effects considered in this assessment are acid deposition resulting from emissions of oxides of nitrogen (NO_x) and sulphur dioxide (SO_2) and direct effects of ground-level concentrations of SO_2, nitrogen dioxide (NO_2) and ozone (O_3) on vegetation. Air emissions and the prediction of deposition and ground-level concentrations within the study areas for these cases are described in Sections 1.6 and 1.8, respectively.

4.5.2.1 Soils Effects Analysis

The Project Case increases the area of the 0.17 keq/ha/yr by 399 ha to 658 ha (Table 4.5-3). The increased area is primarily over the Project Central Plant (Figure 4.5-1). There are also no soil critical load exceedances under the Project Case. Without any soil critical load exceedances, there are no potential effects from acidifying emissions to terrestrial resources provided.

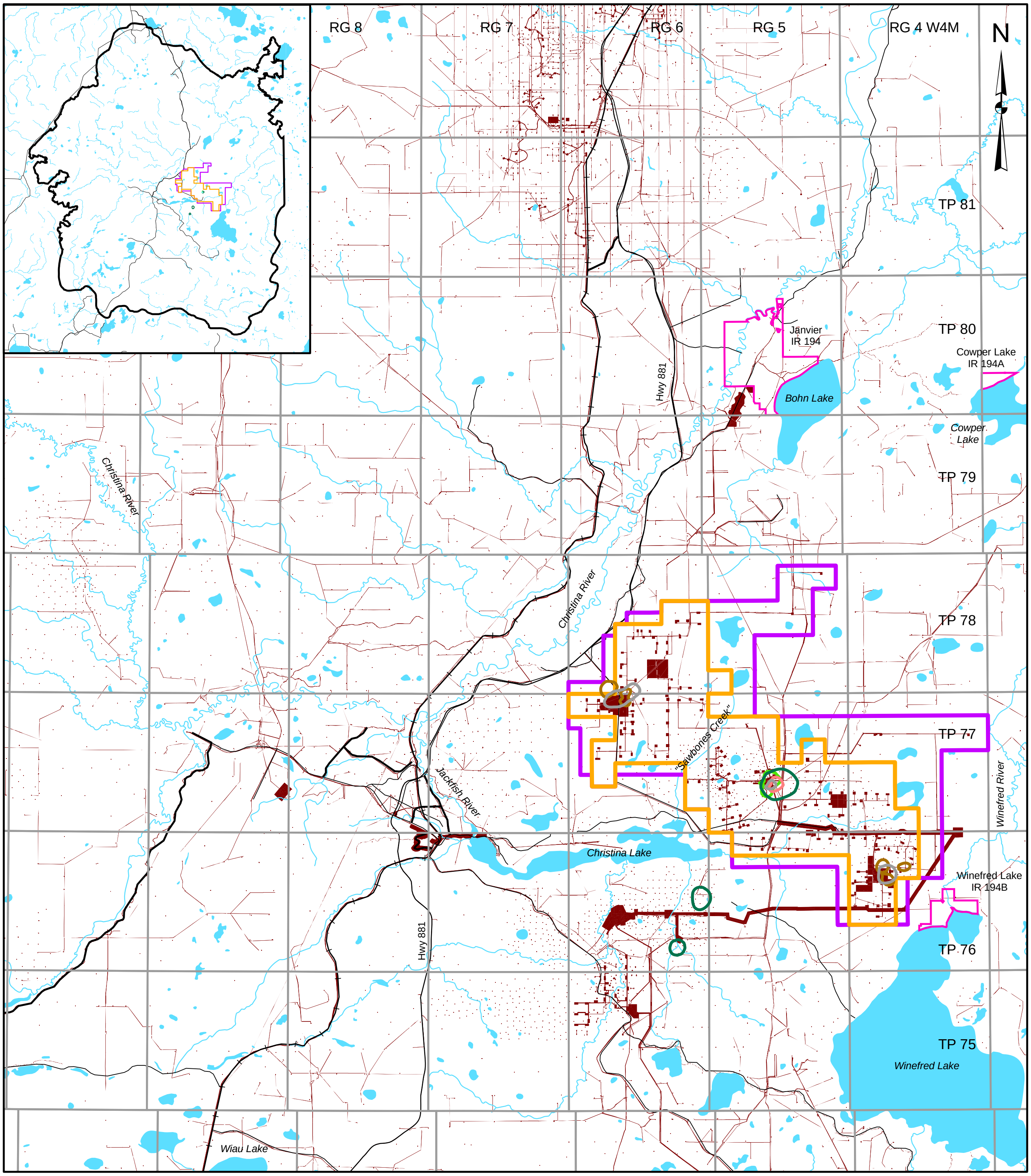
Table 4.5-3 Maximum Extent of Acidification Isopleths in the Regional Study Area – Project Case

Emission Species	Total Spatial Extent – EAC	Total Spatial Extent – Project Case	
	Area [ha]	Area [ha]	Area Change [ha]
PAI - net soil (0.17 keq/ha/yr)[(a)]	259	658	399

(a) CEMA (2004).

Effects Description Criteria

The magnitude of the effects of the Project on soil acidification is rated as negligible due to lack of critical load exceedances (Table 4.5-4). The effects of air emissions on soils are regional in extent. Sources of emissions are considered long-term, as emission sources will be present for the life of the Project. The effects of acid inputs are considered both reversible and irreversible as soils have the potential to slowly recover from acidification over time. In the region, there is an almost constant source of air emissions from present and future projects, so frequency is considered high. The environmental consequence of the predicted effects is negligible.



10 0 10

SCALE 1:400,000 KILOMETRES

LEGEND

- ▭ TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- ▭ TERRESTRIAL RESOURCES LOCAL STUDY AREA
- ▭ MEG LEASE BOUNDARY
- ▭ INDIAN RESERVE
- ■ OPEN WATER
- — RIVER OR STREAM
- — ROADWAY
- ┼ RAILWAY

- ▭ NITROGEN DEPOSITION (0.25 N keq/ha/yr)
- ▭ NO_2 HOURLY ISOPLETH (400 µg/m^3)
- ▭ SOIL NET PAI ISOPLETH (0.17 keq/ha/yr)
- ▭ SO_2 ANNUAL ISOPLETH (10 µg/m^3)
- ▭ SO_2 HOURLY ISOPLETH (450 µg/m^3)

DISTURBED

- ■ PROJECT CASE DISTURBANCE
- — PROJECT CASE LINEAR DISTURBANCE

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

REFERENCE

Alberta digital data obtained from Geomatics Canada (August 2001), AltaLIS Ltd. (September 2004), Veritas DGC Inc. (July 2004), Alberta Pacific Ltd. (April 2004), LANDSAT 5 TM Imagery (2005), used under license.
Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: UTM Zone 12 Datum: NAD 83

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

ISOPLETHS IN THE TERRESTRIAL REGIONAL STUDY AREA - PROJECT CASE

MEG ENERGY CORP.

PROJECT No. 07-1346-0009.9160			SCALE AS SHOWN	REV. 1
DESIGN	AA	12 Nov. 2007	FIGURE: 4.5-1	
GIS	TN	21 Feb. 2008		
CHECK	LD	27 Mar. 2008		
REVIEW	IGG	28 Mar. 2008		

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Table 4.5-4 Effects Description Criteria of Soils Potentially Affected by Acidification – Project Case

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
negative	negligible (0)	regional (+1)	long-term (+2)	reversible/ irreversible (0)	high (+2)	negligible (+5)

Note: Numerical score for ranking of environmental consequence is explained in Volume 2, Section 4.8.

Certainty and Prediction Confidence

The evaluation of changes to soils due to acidification involves the application of the scientific knowledge base and model predictions. As with any prediction there are uncertainties regarding the model's capability to accurately predict effects. The major sources of uncertainty include those associated with the use of critical loads, model predictions of soil net PAI, data quantity and quality and the knowledge base concerning the relationship between soil net PAI and acid sensitivity of soils in terrestrial RSA.

Several qualifications apply to the predicted effects from acidifying emissions. First, the soil net PAI values are generated by model simulations and thus subject to inherent limitations associated with the specific model being used.

Second, the soil critical loads and sensitivity classes are based on literature (CASA 1996; Holowaychuk and Fessenden 1987; Turchenek et al. 1998) and not verified on project-specific basis field data.

By applying critical loads and sensitivity classes based on the scientific literature, confidence can be given in that the most applicable measures have been used. The critical loads have been developed by leading authorities (CASA 1996) and are accepted by the provincial government. The scientific basis behind these critical loads lends a reasonable level of confidence to the assessment.

The area potentially affected can be assessed with a reasonable degree of certainty using the currently available information. Thus, the percent change of areas potentially affected is a reasonable measure of the impacts of each assessment case. As the knowledge base increases, the level of uncertainty regarding the analysis will decrease. The knowledge base is reviewed in Appendix 3-XII, Sections 2 and 3.

Scientific uncertainty with modelled soil net PAI and data quality and quantity is reviewed in Appendix 3-XII. The models used (i.e., CALPUFF) are the most applicable and minimize the uncertainty involved with emission levels. Application of these models increases the confidence of the analysis, and is applied to the prediction of potential effects to ecological receptors.

4.5.2.2 Terrestrial Vegetation and Wetlands Effects Analysis

Sulphur Dioxide

The SO_2 isopleths are localized over the Project Central Plant (Figure 4.5-1). All increases in SO_2 from the EAC to the Project Case account for less than 1% of the terrestrial RSA area (Table 4.5-5). Hourly concentrations above the 450 $\mu g/m^3$ AAAQO objective account for 86 ha over vegetated areas in the Project Case. There are no concentrations above the daily (150 $\mu g/m^3$) or annual (30 $\mu g/m^3$) AAAQOs for the Project Case. The annual 10 $\mu g/m^3$ level isopleth is a WHO (2000) guideline for the protection of lichens; it is below the AAAQO annual objective of 30 $\mu g/m^3$. Project emissions above the 10 $\mu g/m^3$ SO_2 annual isopleth in the terrestrial RSA account for 38 ha over vegetated areas.

Table 4.5-5 Maximum Extent of Emission Isopleths in the Regional Study Area – Project Case

Emission Species	Areas of Exceedance Over Vegetated Areas – EAC	Areas of Exceedance Over Vegetated Areas – Project Case	
	Area [ha]	Area [ha]	Area Change From EAC [ha]
SO_2 - annual (10 $\mu g/m^3$)[a]	0	38	38
SO_2 - hourly (450 $\mu g/m^3$)[b]	0	86	86
NO_2 - hourly (400 $\mu g/m^3$)[b]	0	169	169
nitrogen deposition – annual (0.25 N keq/ha/yr)[c]	13	123	110

[a] WHO (2000).

[b] AAAQO Objectives.

[c] Vitt et al. (2002).

Nitrogen Dioxide

The NO_2 isopleth is localized over the Project Central Plant (Figure 4.5-1). There are no annual (60 $\mu g/m^3$) or daily (200 $\mu g/m^3$) concentrations above the AAAQO for the Project Case. The Project increases size of the vegetated areas above the hourly (400 $\mu g/m^3$) NO_2 AAAQO objective in the terrestrial RSA by 169 ha (Table 4.5-5).

Nitrogen Deposition

Under the Project Case, there is an incremental change in nitrogen deposition above the 0.25 keq N/ha/yr critical load, where vegetation is considered to have the potential to respond to anthropogenic sources of nitrogen (Vitt et al. 2002). Over vegetated areas, the Project increases the nitrogen deposition (0.25 keq N/ha/yr) from 13 ha to 123 ha, a 110 ha increase. There are no areas over 2.0 keq N/ha/yr, the level considered to negatively affect plant growth. The area above the 0.25 keq N/ha/yr is localized over the Central Plant and Plants 3A and 3B (Figure 4.5-1).

Ground-Level Ozone

Monitored ozone levels in the region are below both the 1-hour AAAQO and 8-hour Canada-Wide Standards (Section 1.5.2.4). In the Air Quality modelling domain the Project is predicted to increase ozone precursor emissions by 0.9% (Section 1.8.5.1), which could increase peak ozone concentrations by approximately 0.3 ppb. Under these conditions, the effect of ozone on terrestrial vegetation and wetlands is likely negligible.

Effects Description Criteria

The effects associated with the Project are detailed in Table 4.5-6. The direction of effects is negative for all parameters. The effects of air emissions on vegetation are regional in extent. Sources of emissions are considered long-term, as emission sources will be present for the life of the Project. Effects are considered reversible for all emissions. Once emissions cease, vegetation recovery and regeneration are expected.

Table 4.5-6 Effects Description Criteria of Terrestrial Vegetation and Wetlands Potentially Affected by Emissions – Project Case

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
SO_2 – AAAQO	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
SO_2 – WHO	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
NO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
nitrogen deposition	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
ground-level ozone	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical score for ranking environmental consequence is explained in Volume 2, Section 4.8.

In the region, there will be an almost constant source of air emissions from existing and approved projects and the Project, so frequency is considered high.

The magnitude of the relative contribution of the Project on regional SO_2, NO_2, nitrogen deposition and ground-level ozone concentrations are negligible. The relevant isopleths are localized over the Central Plant and/or Plants 3A and 3B and other developments south of the Project (Figure 4.5-1) and there is no appreciable difference between the EAC and Project Case (less than 1% of the RSA). Overall the environmental consequence of air emissions from the Project Case on terrestrial vegetation and wetlands is negligible.

Certainty and Prediction Confidence

The confidence of the analysis on the effects of air emissions on terrestrial vegetation and wetlands depends on several factors including:

- understanding how vegetation will react to changes in air emissions;
- the accuracy of predicted air emissions;
- the accuracy of critical loads and emission levels to indicate points where impacts can occur; and
- the applicability and accuracy of the models used to predict impacts to ecological receptors.

The effects assessment of air emissions on vegetation, which is based on available information, the applicability of information on surrogates and on professional opinion, involves an understanding of:

- the effects of air emissions on vegetation;
- natural/ecological processes now and in the future; and
- present and future properties of the affected vegetation.

The knowledge base on the effects of air emissions is reviewed in Appendix 3-XII, Sections 2 and 3. Studies include laboratory and field observations and experiments. Confidence increases as the knowledge base grows and allows for predictions to become increasingly accurate.

Scientific uncertainty with predicting air emissions is reviewed in Appendix 3-XII. The models used (i.e., CALPUFF) are the most applicable for use in the Oil Sands Region and minimize the uncertainty involved with emission levels. Application of these models increases the confidence of the analysis and the prediction of potential effects to ecological receptors.

The models used to assess the potential effects of air emissions on vegetation are based on comparing reviewed vegetation sensitivities to applicable critical loads, objectives and guidelines. These standards have been adapted from recommendations by leading authorities (CASA, WHO and the provincial and federal governments). The scientific basis behind these standards lends a reasonable level of confidence to the assessment.

The critical loads, objectives and guidelines used are built with a substantial level of conservatism. As a result, there is confidence that predicted air emissions that may affect ecological receptors have not been underestimated.

4.5.2.3 Wildlife and Wildlife Habitat Effects Analysis

Sulphur Dioxide

The SO_2 isopleths are localized over the Central Plant and Plants 3A and 3B (Figure 4.5-1). All increases in SO_2 from the EAC to the Project Case account for less than 1% of the terrestrial RSA. The hourly SO_2 AAAQO of 450 µg/m^3 is predicted to be exceeded over 49 ha of high-quality caribou habitat. The annual 10 µg/m^3 level isopleth is a WHO (2000) guideline for the protection of lichens; it is below the AAAQO annual guideline of 30 µg/m^3. Project emissions within the 10 µg/m^3 SO_2 annual isopleth in the RSA account for 33 ha of high-quality caribou habitat.

Nitrogen Dioxide

The NO_2 isopleth is localized over the Central Plant (Figure 4.5-1). There are no annual (60 µg/m^3) or daily (200 µg/m^3) concentrations above the AAAQO for the Project Case. The Project increases the size of the hourly (400 µg/m^3) NO_2 isopleths in the RSA by 72 ha over areas of high-quality caribou habitat.

Effects Description Criteria

The effects associated with the Project are detailed in Table 4.5-7. The direction of effects is negative for all parameters. The effects of air emissions on vegetation are regional in extent. Sources of emissions are considered long-term, as emission sources will be present for the life of the Project. Effects are considered reversible for all emissions. Once emissions cease, vegetation recovery and regeneration are expected.

Table 4.5-7 Effects Description Criteria of Regional Caribou Habitat Potentially Affected by Emissions – Project Case

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
NO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical score for ranking environmental consequence is explained in Volume 2, Section 4.8.

In the region, there will be an almost constant source of air emissions from existing and approved projects and the Project, so frequency is considered high.

The magnitude of the relative contribution of the Project on regional SO_2 and NO_2 is negligible. The relevant isopleths are localized over the Central Plant and/or Plants 3A and 3B (Figure 4.5-1) and there is no appreciable difference between the EAC and Project Case. Overall, the environmental consequence of air emissions from the Project Case on terrestrial vegetation and wetlands is negligible.

Certainty and Prediction Confidence

Certainty associated with effects to wildlife habitat are the same as those for terrestrial vegetation and wetlands, as described earlier in this section.

4.6 PLANNED DEVELOPMENT CASE

The PDC assessment included an evaluation of atmospheric releases from the Project, in combination with the emissions from existing, approved and planned developments in the region. The developments considered in this case are listed Volume 2, Section 5 of the EIA. The PDC air quality predictions of regional SO_2, NO_x and soil net PAI are presented in Section 1.9. The following sections present the assessment of effects of PDC air emissions on aquatic and terrestrial resources.

4.6.1 Aquatic Resources Effects Analysis

Lake Acidification

Of the 416 lakes assessed, lake net PAI values under the PDC were above the corresponding critical loads for 22 lakes. Critical loads of acidity, lake net PAI values, percentage changes compared to the EAC and total nitrogen deposition rates for 22 lakes with critical load exceedances under the PDC are provided in

Table 4.6-1. Predicted acid deposition under the PDC was higher than the critical load for one additional lake (P7) compared to the EAC. For lakes with predicted critical load exceedances under the EAC, the increases in acid input rates relative to the EAC ranged from 1 to 28%.

Available approaches are not sufficiently refined to allow prediction of the magnitude of the reduction in pH in potentially affected surface waters, or the time frame of the potential effects. To predict effects on aquatic life, it is desirable to estimate the likely degree and rate of reduction in pH because effects on biota are reported in terms of pH in North America. Based on the observed pH of these lakes under background conditions, many of them are expected to have low biodiversity and likely do not support sport fish (Appendix 3-XII, Section 2.1.5).

Lake 152 (P7), where acid input is predicted to exceed the critical load under the PDC, is over 100 km away from the Project. Similarly, all of the lakes where acid input is predicted to exceed critical loads under the PDC (and the EAC) are outside the Air Quality RSA and are over 60 km away from the Project. The Project's contribution to effects at this distance is negligible (i.e., the Project results in a less than 1% change in deposition relative to the EAC).

The effects on regional lakes are considered reversible taking into account that successful mitigation of lake acidification and natural recovery have been demonstrated by several studies (Gunn and Keller 1990; Havas 1990; Porcella et al. 1990; Locke et al. 1994; MacIsaac et al. 1986; Nicholls et al. 1992).

The analysis of air emissions effects is conservative because simultaneous emissions at the fully approved rates from all developments are assumed; the assessment does not take into account timing of developments. Of the 22 lakes shown in Table 4.6-1, 14 are monitored by RAMP. Although emissions have been higher than background for the last 15 years, no trends related to air emissions effects have been observed to date in RAMP lakes, including those that are currently considered to be acidified (i.e., have a pH below 6; Appendix 3-XII, Section 3.1).

Episodic Stream Acidification

Emissions of SO_2 for the PDC account for a 14% increase in regional SO_2 emissions compared to the EAC (Section 1.9). Emissions of NO_X for the PDC result in an approximately 33% increase in regional NO_X emissions compared to the EAC (Section 1.9). Nitrogen deposition is not predicted to exceed the threshold of 8 kg N/ha/yr, where nitrogen leeching leading to episodic acidification is possible, within 100 km of the Project which is outside the RSA. Therefore, deposited nitrogen is not expected to contribute to acidification under the PDC.

Table 4.6-1 Acid Input and Nitrogen Deposition Rates for 22 Lakes With Critical Load Exceedances – Planned Development Case

Lake Identifier(a)	Lake Name/ Original Identifier	Location in Regional Study Area	Distance [km](b)	Direction(b)	pH	Critical Load of Acidity [keq/ha/yr]	Lake Net PAI [keq/ha/yr]					Nitrogen Deposition [kg/ha/yr]			
							Calibrated Background(c)	EAC	Project Case	PDC	PDC % Increase Over EAC	AENV Background(d)	EAC	Project Case	PDC
145	28(e), 28 (290)(f)		64	NNW	5.9	0.016	0.019	0.081	0.081	0.099	23%	1.2	2.0	2.0	2.4
178	30(e)		65	NNW	5.2	-0.095	0.020	0.082	0.082	0.101	23%	1.2	2.0	2.0	2.4
143	25(e), 25 (287)(f)		67	NNW	5.2	-0.054	0.030	0.095	0.096	0.115	21%	1.2	2.0	2.0	2.4
117	26(e), A26(f)		68	NNW	5.6	0.009	0.032	0.100	0.101	0.122	21%	1.2	2.0	2.0	2.4
179	31(e)		70	NNW	5.6	-0.060	0.061	0.119	0.119	0.138	16%	1.2	1.9	1.9	2.3
116	24(e), A24(f)		70	NNW	4.7	-0.103	0.027	0.092	0.092	0.112	22%	1.2	2.0	2.0	2.4
144	27(e), 27 (289)(f)		72	NW	6.5	0.033	0.015	0.070	0.070	0.089	28%	1.2	1.9	1.9	2.3
115	21(e), A21(f)		74	NNW	5.0	-0.068	0.133	0.204	0.204	0.227	11%	1.2	2.0	2.0	2.4
118	29(e), A29(f)		76	NW	5.8	-0.005	0.018	0.061	0.061	0.077	28%	1.2	1.7	1.7	2.0
34	UNL1(g)		82	N	6.1	0.044	0.047	0.219	0.219	0.243	11%	1.2	2.4	2.4	2.8
39	L10(g)		83	NNW	5.8	0.019	0.084	0.174	0.175	0.204	17%	1.2	2.2	2.2	2.7
40	L11(g)		84	NNW	6.0	0.084	0.133	0.224	0.225	0.254	13%	1.2	2.2	2.2	2.7
121	59(e), A59(f)		137	WNW	5.2	0.023	0.043	0.062	0.062	0.066	7%	1.3	1.5	1.5	1.6
83	L7(h),(f)		159	N	6.4	0.187	0.114	0.233	0.234	0.251	7%	1.1	2.5	2.5	2.9
150	P27(i),(f)		165	N	5.2	-0.019	0.027	0.159	0.159	0.179	13%	1.1	2.8	2.8	3.2
82	170(e), 14(j), L4(h), A170 (L4)(f)		165	N	6.0	0.069	0.119	0.250	0.250	0.270	8%	1.1	2.8	2.8	3.2
152	P7(i),(f)		174	N	6.4	0.151	0.016	0.150	0.150	0.168	13%	1.1	2.9	2.9	3.3
464	PM1(i)		179	N	4.2	-0.273	0.039	0.200	0.200	0.224	12%	1.1	3.7	3.7	4.2
81	L1(h),(f)		181	N	6.3	0.183	0.076	0.226	0.226	0.251	11%	1.1	3.7	3.7	4.3
469	PT2(i)		249	NNW	5.0	0.231	0.385	0.410	0.410	0.414	1%	1.0	1.3	1.3	1.4
96	28(3), L28(h), (f)		280	NNW	5.2	-0.013	0.036	0.054	0.054	0.056	5%	1.1	1.2	1.2	1.3
97	Clayton		283	NNW	4.3	-0.084	0.010	0.025	0.025	0.028	10%	1.0	1.2	1.2	1.2

(a) Identifier used on map showing lake locations.

(b) Distance and direction relative to the Project.

(c) Estimated background acid input based on measured nitrate and sulphate concentrations in lakes (Appendix 3-XII, Section 5.2).

(d) Estimated nitrogen deposition rates from the AENV RELAD modelling (Cheng 2001).

(e) Identifier used by previous EIAs; refer to Appendix 3-XII, Section 5.3.

(f) Identifier used by RAMP (2005).

(g) Identifier used by Saffran and Trew (1996).

(h) Identifier used by WRS (2004) for a survey of 34 lakes conducted by Alberta-Pacific Forest Industries in 1999.

(i) Identifier used by WRS (2004) for one hundred ponds sampled within the Oil Sands Region during September 2000.

(j) Identifier used by Erickson (1987).

Note: Acid deposition rates above the critical load are shaded.
Percentage changes were calculated based on data with more than three decimals and does not support direct comparison of the rounded lake net PAI values provided in this table.

The predicted maximum depression in snowmelt pH due to emissions from the PDC is 0.44 pH units below EAC values. In the area south of Fort McMurray, in the Air Quality RSA and within 60 km of the Project, the maximum depression is 0.16 pH units (Appendix 3-XII, Section 5.5). The increased emissions under the PDC and subsequent changes in snowmelt pH are unlikely to result in measurable changes in episodic acidification in streams. The maximum change in pH in streams would be lower than the conservatively predicted values in Appendix 3-XII, Section 5.5 due to several factors. For example, groundwater contribution to stream flow would buffer stream water and infiltration of snowmelt to soils would allow for removal of nitrate.

A discussion of qualitative information related to stream sensitivity, including the results of the WRS (2002) study is provided in Appendix 3-XII, Section 5.1.2. The analysis indicates that streams in the area surrounding the Project are unlikely to be sensitive to acidification. The minimum stream alkalinity value (520 µeq/L) was measured in Unnamed Watercourse 1-04 just to the northwest of the Project area and is more than twice the threshold value of 200 µeq/L, below which a stream is designated acid sensitive.

Based on the above weight-of-evidence approach, potential effects on streams in the form of episodic acidification is unlikely.

Effects Description Criteria

The effects of acidifying emissions under the PDC on local and regional surface waters are classified in Table 4.6-2. Effects were classified within 60 km of the Project, where a contribution of the Project to cumulative effects is possible.

Table 4.6-2 Effects Description Criteria for Acidifying Emissions on Regional Waterbodies – Planned Development Case

Effect and Waterbody	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Acidification of local and regional lakes	negative	negligible (0)	regional (+1)	long-term (+2)	high (+2)	reversible (-3)	negligible (+2)
Episodic acidification of local and regional streams	negative	negligible (0)	regional (+1)	long-term (+2)	high (+2)	reversible (-3)	negligible (+2)

Note: Numerical score for ranking of environmental consequence is explained in Volume 2, Section 4.8.

The magnitude of effects from regional emissions of acidifying substances on local and regional lakes is negligible within 60 km of the Project. Lakes beyond this distance were not included in the classification of effects because the Project is not expected to contribute to cumulative effects beyond 60 km. The effects on these lakes are negative in direction and regional in geographic extent. Effect duration is classified as long-term, corresponding to the life of the Project. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The environmental consequence of the predicted effects is negligible.

The magnitude of the effects from emissions of acidifying substances on local and regional streams is negligible. The effects are negative in direction and regional in geographic extent. Effect duration is classified as long-term, corresponding to the life of the Project. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The environmental consequence of the predicted effects is negligible.

4.6.2 Terrestrial Resources Effects Analysis

4.6.2.1 Soils Effects Analysis

Under the PDC, the area of the 0.17 keq/ha/yr increase by 502 ha to 761 ha (Table 4.6-3, Figure 4.6-1). There are no soil critical load exceedances under the PDC. Without any soil critical load exceedances, there are no potential impacts from acidifying emissions to terrestrial resources predicted.

Table 4.6-3 Maximum Extent of Acidification Isopleths in the Regional Study Area – Planned Development Case

Emission Species	Existing and Approved Case	Project Case		PDC	
	Area/ [ha]	Area [ha]	Area Change From EAC [ha]	Area [ha]	Area Change From EAC [ha]
PAI - net soil (0.17 keq/ha/yr)[a]	259	658	399	761	502

[a] CEMA (2004).

Effects Description Criteria

The magnitude of effects of the Project and planned developments on soil acidification is rated as negligible due to lack of critical load exceedances (Table 4.6-4). The effects of air emissions on soils are regional in extent. Sources of emissions are considered long-term, as emission sources will be present for the life of the Project. The effects of acid inputs are considered both reversible and irreversible as soils have the potential to slowly recover from acidification over time. In the region, there is an almost constant source of air emissions from present and future projects, so frequency is considered high. The environmental consequence of the predicted effects is negligible.

Table 4.6-4 Effects Description Criteria of Soils Potentially Affected by Acidification – Planned Development Case

Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
negative	negligible (0)	regional (+1)	long-term (+2)	reversible/irreversible (0)	high (+2)	negligible (+5)

Note: Numerical score for ranking of environmental consequence is explained in Volume 2, Section 4.8.

4.6.2.2 Terrestrial Vegetation and Wetlands Effects Assessment

Sulphur Dioxide

The SO_2 isopleths under the PDC are localized over the Central Plant (Figure 4.6-1). There are no appreciable increases of SO_2 from the EAC to the PDC (Table 4.6-3). The vegetated area within hourly concentrations above the 450 µg/m^3 AAAQO objective increases by 87 ha from the EAC to the PDC. There are no concentrations above the daily (150 µg/m^3) or annual (30 µg/m^3) AAAQOs for the PDC. The 10 µg/m^3 level isopleth is a WHO (2000) guideline for the protection of lichens; it is below the AAAQO guideline of 30 µg/m^3. The PDC emissions above the 10 µg/m^3 annual isopleth in the terrestrial RSA account for 37 ha over vegetated areas.

Nitrogen Dioxide

The hourly NO_2 400 µg/m^3 isopleth is localized over the Plants 3A and 3B (Figure 4.6-1). Vegetated areas within the hourly NO_2 400 µg/m^3 AAAQO isopleth increase by 100 ha (Table 4.6-5). There are no predicted annual (60 µg/m^3) or daily (200 µg/m^3) concentrations above the AAAQO for the PDC.

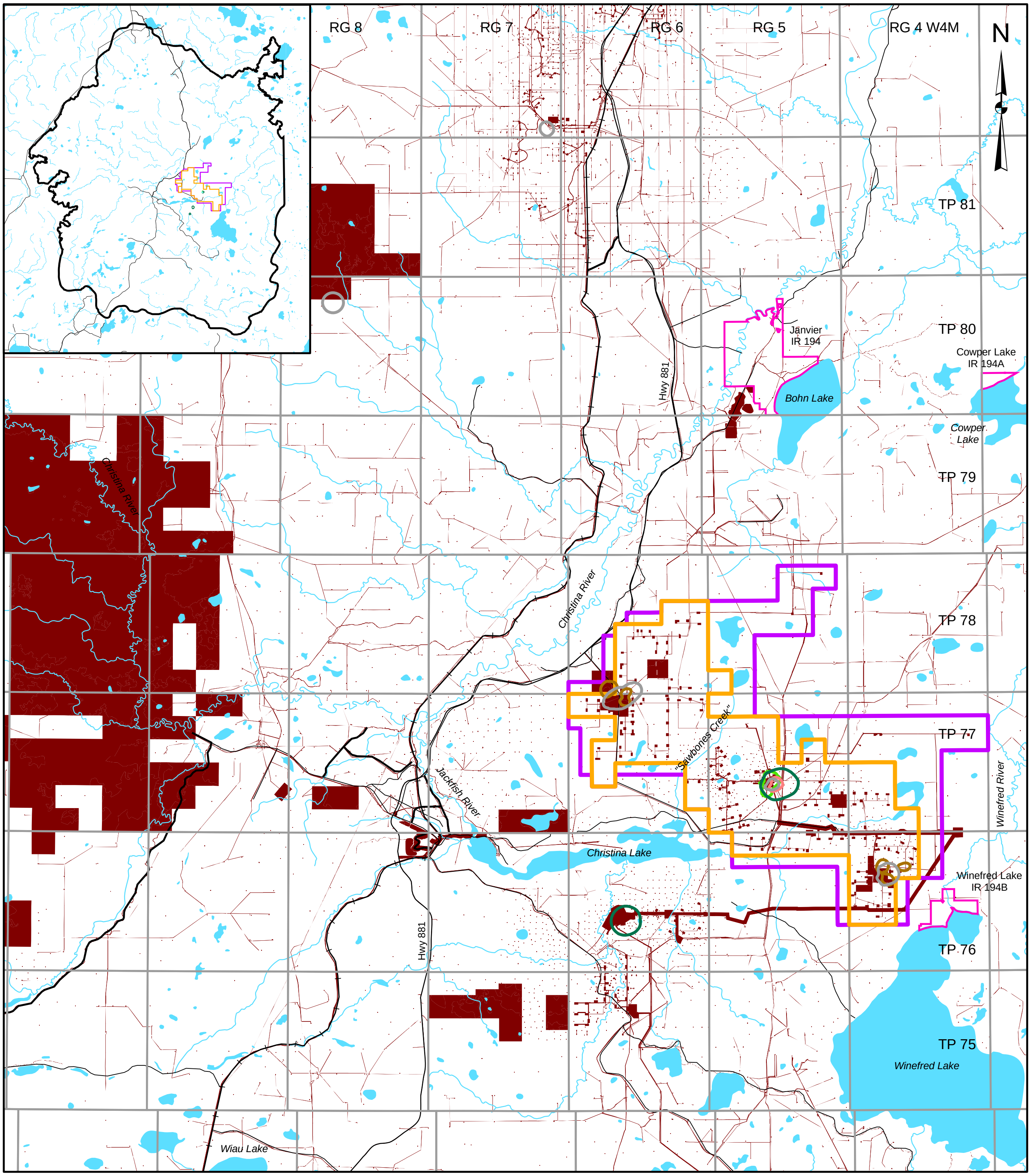
Table 4.6-5 Maximum Extent of Emission Isopleths in the Regional Study Area – Planned Development Case

Emission Species	Areas of Exceedance Over Vegetated Areas – EAC	Areas of Exceedance Over Vegetated Areas – Project Case		Areas of Exceedance Over Vegetated Areas – PDC	
	Area [ha]	Area [ha]	Area Change from EAC [ha]	Area [ha]	Area Change from EAC [ha]
SO_2 - annual (10 µg/m^3)[(a)]	0	38	38	37	37
SO_2 - hourly (450 µg/m^3)[(b)]	0	86	86	87	87
NO_2 - hourly (400 µg/m^3)[(b)]	0	169	169	100	100
nitrogen deposition – annual (0.25 N keq/ha/yr)[(c)]	13	123	110	382	369

[(a)] WHO (2000).

[(b)] AAAQO Objectives.

[(c)] Vitt et al. (2002).



10 0 10

SCALE 1:400,000 KILOMETRES

LEGEND

- ⬛ TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- 🟪 TERRESTRIAL RESOURCES LOCAL STUDY AREA
- 🟧 MEG LEASE BOUNDARY
- ☐ INDIAN RESERVE
- 🟦 OPEN WATER
- — RIVER OR STREAM
- — ROADWAY
- —+— RAILWAY
- ○ NITROGEN DEPOSITION (0.25 N keq/ha/yr)
- ○ NO_2 HOURLY ISOPLETH (400 µg/m^3)
- ○ SOIL NET PAI ISOPLETH (0.17 keq/ha/yr)
- ○ SO_2 ANNUAL ISOPLETH (10 µg/m^3)
- ○ SO_2 HOURLY ISOPLETH (450 µg/m^3)

DISTURBED

- 🟥 PDC DISTURBANCE
- — PDC LINEAR DISTURBANCE

NOTE

Unnamed watercourse locally known as "Sawbones Creek"

REFERENCE

Alberta digital data obtained from Geomatics Canada (August 2001), AltaLIS Ltd. (September 2004), Veritas DGC Inc. (July 2004), Alberta Pacific Ltd. (April 2004), LANDSAT 5 TM Imagery (2005), used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: UTM Zone 12 Datum: NAD 83

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

ISOPLETHS IN THE TERRESTRIAL REGIONAL STUDY AREA - PLANNED DEVELOPMENT CASE

MEG ENERGY CORP.

PROJECT No. 07-1346-0009.9160			SCALE AS SHOWN	REV. 1
DESIGN	AA	12 Nov. 2007	FIGURE: 4.6-1	
GIS	TN	21 Feb. 2008		
CHECK	LD	27 Mar. 2008		
REVIEW	IGG	28 Mar. 2008		

I:\CLIENTS\MEG\07-1346-0009\mapping\mxd\Air\rsa_pdc_overview.mxd

Nitrogen Deposition

Under the PDC, there is an incremental change in nitrogen deposition above the 0.25 keq N/ha/yr critical load where vegetation is considered to have the potential to respond to anthropogenic sources of nitrogen (Vitt et al. 2002). Over vegetated areas, the PDC increases nitrogen deposition (0.25 keq N/ha/yr) from 13 ha to 382 ha, a 369 ha increase. There are no areas over 2.0 keq N/ha/yr, the level considered to negatively affect plant growth. The area above the 0.25 keq N/ha/yr is localized over the Central Plant and other localized areas north of the Project (Figure 4.6-1).

Effects Description Criteria

The effects associated with the Project and planned developments are detailed in Table 4.6-6. The direction of effects is negative. The effects of air emissions on vegetation are regional in extent. Sources of emissions are considered long-term, as emission sources will be present for the life of the Project and planned developments. Effects are considered reversible for all emissions. Once emissions cease, vegetation recovery and regeneration are expected.

Table 4.6-6 Effects Description Criteria of Terrestrial Vegetation and Wetlands Potentially Affected by Emissions – Planned Development Case

Parameter	Impact Assessment Criteria						
	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
SO_2 – AAAQO	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
SO_2 – WHO	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
NO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
nitrogen deposition	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical score for ranking environmental consequence is explained in Volume 2, Section 4.8.

In the region, there is an almost constant source of air emissions from present and future projects, so frequency is considered high.

The magnitude of the relative contribution of the Project and planned developments on regional SO_2, NO_2 and nitrogen deposition are negligible. The relevant isopleths are localized over the Project plant sites and other developments in the RSA (Figure 4.6-1) and there is no appreciable difference between the EAC and the PDC (less than 1% of the RSA). Overall the environmental consequence of air emissions from the Project and planned developments on terrestrial vegetation and the wetlands is negligible.

4.6.2.3 Wildlife and Wildlife Habitat Effects Analysis

Sulphur Dioxide

The SO_2 isopleths are localized over the Central Plant site (Figure 4.6-1). All increases in SO_2 from the EAC to the PDC account for less than 1% of the RSA area. The hourly SO_2 AAAQO of 450 µg/m^3 is predicted to be exceeded over 49 ha of high-quality caribou habitat. The annual 10 µg/m^3 level isopleth is a WHO (2000) guideline for the protection of lichens; it is below the AAAQO annual guideline of 30 µg/m^3. Project and PDC emissions within the 10 µg/m^3 SO_2 annual isopleth in the RSA account for 32 ha of high-quality caribou habitat.

Nitrogen Dioxide

The NO_2 isopleth is localized over the Central Plant and Plants 3A and 3B (Figure 4.6-1). There are no annual (60 µg/m^3) or daily (200 µg/m^3) concentrations above the AAAQO for the PDC. In the PDC, the hourly (400 µg/m^3) NO_2 isopleth covers 49 ha over areas of high-quality caribou habitat.

Effects Description Criteria

The effects associated with the PDC are detailed in Table 4.6-7. The direction of effects is negative for all parameters. The effects of air emissions on vegetation are regional in extent. Sources of emissions are considered long-term, as emission sources will be present for the life of the Project and planned developments. Effects are considered reversible for all emissions. Once emissions cease, vegetation recovery and regeneration are expected.

Table 4.6-7 Effects Description Criteria of Regional Caribou Habitat Potentially Affected by Emissions – Planned Development Case

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
NO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical score for ranking environmental consequence is explained in Volume 2, Section 4.8.

In the region, there is an almost constant source of air emissions from present and future projects, so frequency is considered high.

The magnitude of the relative contribution of the Project on regional SO_2 and NO_2 are negligible. The relevant isopleths are localized over the Project Plant Sites (Figure 4.4-2) and there is no appreciable difference between the EAC and PDC (less than 1% of the RSA). Overall the environmental consequence of air emissions from the PDC on terrestrial vegetation and wetlands is negligible.

4.7 CONCLUSIONS

The air emissions effects on ecological receptors assessment considered potential effects of air emissions to aquatic and terrestrial resources. The air emissions were predicted within the air quality modelling domain (Section 1.2). Aquatic resources were assessed within waterbodies in the air quality modelling domain. Terrestrial resources were assessed within the Terrestrial Resources RSA.

4.7.1 Aquatic Resources

Under the EAC, lake net PAI was above the lake-specific critical loads for 21 of the 416 lakes included in the assessment. The background lake net PAI was above the critical load for 18 of these lakes. These results suggest that a small number of lakes in the Oil Sands Region may be at risk of acidification under the EAC and under background conditions.

Emissions from the Project were not predicted to result in additional exceedances of the critical load under the Project Case. Project-related increases in acid deposition to lakes with exceedances under the EAC were small (less than 0.6%). Therefore, emissions from the Project were predicted to have a negligible potential to affect water quality or aquatic life in regional lakes.

One additional lake 152 (P7) is predicted to exceed the critical load under the PDC (Table 4.6-1). All of the lakes predicted to potentially exceed critical loads under the PDC (and the EAC) are outside of the Air Quality RSA and over 60 km away from the Project (Table 6.4-1). The Project contribution to effects at this distance is negligible.

The increase in regional emissions due to the Project and subsequent changes in snowmelt pH were predicted to be too small to result in a measurable change in episodic stream acidification under the EAC. Under the PDC, the weight of evidence suggests that episodic stream acidification is unlikely.

4.7.2 Terrestrial Resources

There are no soil critical load exceedances under the Project Case or PDC. Without any soil critical load exceedances, there are no potential effects from acidifying emissions to terrestrial resources predicted.

The SO_2, NO_2 and nitrogen deposition isopleths relevant to the assessment of terrestrial vegetation and wetlands, and for wildlife habitat are localized over the

Project and other developments in the RSA. There are no appreciable increases in the size of the isopleths from the EAC to the Project Case or PDC. All increases are small resulting in negligible environmental consequences.

The area above the 0.25 keq N/ha/yr is localized over the Central Plant and Plants 3A and 3B (and other planned developments in the PDC) and will have a negligible effect on vegetated areas under both the Project Case (Figure 4.5-1) and PDC (Figure 4.6-1).

The project is predicted to increase ozone precursor emissions by less than 5% in the Air Quality RSA and modelling domain (Section 1.8.3, Table 1.8-22), which is too small to result in a measurable change in ground-level ozone concentrations. Under these conditions, the effect of ozone on terrestrial vegetation and wetlands is considered negligible.

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GLOSSARY

3D Seismic	A remote sensing tool that uses sound waves to image the subsurface.
Abiotic	Non-living factors that influence an ecosystem, such as climate, geology and soil characteristics.
Aboriginal People	The descendents of the original inhabitants of Canada. Pursuant to the Canadian Constitution Act, 1982, and Schedule B of the Canada Act, 1982, (Chapter 11, Section 35) Aboriginal peoples includes the Indian, Inuit and Métis peoples of Canada. The Constitution does not define membership in individual groups.
Abscission	The separation of part of a plant from the main plant body - most commonly, the falling of leaves or the dropping of fruit.
Acid Cation	Hydrogen ion or metal ion that can hydrolyse water to produce hydrogen ions (e.g., ionic forms of aluminum, manganese and iron).
Acid Neutralizing Capacity (ANC)	The equivalent capacity of a solution to neutralize strong acids. Acid Neutralizing Capacity can be calculated as the difference between non-marine base cations and strong anions.
Acid Pulse	Acid pulse (or episodic acidification) refers to a rapid drop in pH in surface waters over a short period.
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.
Acidophillic	Acid loving, as in a plant which prefers acidic soils
Admixing	The dilution of topsoil with subsoil, spoil or waste material, with the result that topsoil quality is reduced. Admixing can result in adverse changes in topsoil texture, poor soil aggregation and structure, loss of organic matter and decrease in friability.
Aeolian	Sedimentary deposits arranged by wind, such as sand, silt and other loose substrates in dunes.
Air Shed	The geographic area requiring unified management to achieve air pollution control.

Albedo	The ratio of reflected solar radiation to the total incoming solar radiation received at the surface.
Alberta Ambient Air Quality Guidelines	A document established under Section 14 of the Environmental Protection and Enhancement Act (EPEA). The guidelines are part of the Alberta air quality management system.
Alberta Ambient Air Quality Objective (AAAQO)	Alberta Ambient Air Quality Objectives are guidelines established for release of air compounds. The AAAQOs form an integral part of the management of air quality in the province and are used for reporting the state of the environment, establishing approval conditions, evaluating proposed facilities with air emissions, assessing compliance near major air emission sources and guiding monitoring programs.
Alberta Energy and Utilities Board (EUB)	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. Effective January 1, 2008, the Alberta Energy and Utilities Board (EUB) has been realigned into two separate regulatory bodies: • the Energy Resources Conservation Board (ERCB), which regulates the oil and gas industry, and • the Alberta Utilities Commission (AUC), which regulates the utilities industry.
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 Surface Water Quality Objectives (ASWQO)	Numerical concentrations or narrative statements established to support and protect the designated uses of water. These are minimum levels of quality, developed for Alberta watersheds, below which no waterbody is permitted to deteriorate.

Alberta Sustainable Resource Development (ASRD)	Alberta Ministry responsible for administering the development of Alberta's forests, public lands, and fish and wildlife resources.
Alberta Vegetation Inventory (AVI) (AEO 1991)	A GIS mapping system and digital forest inventory. It includes tree species, height, canopy closure, stand age, site conditions. and non-commercial vegetated and nonvegetated cover types.
Alberta Wetlands Inventory (AWI)	A digital wetlands inventory and GIS mapping system that includes wetlands class, amount of vegetation cover, presence or absence of permafrost, presence or absence of internal lawns, and internal lawn and vegetation cover type.
Alkalinity	A measure of water's capacity to neutralize an acid, expressed as an equivalent of calcium carbonate It indicates the presence of carbonates, bicarbonates and hydroxides and less significantly, borates, silicates, phosphates and organic substances.
Alleles/Allelic Diversity	One member of a pair or series of genes that occupy a specific position on a specific chromosome/the variety, distribution and abundance of different alleles within a population.
Alluvial	Soil or earth material which has been deposited by running water, as in a riverbed, floodplain, or delta.
Ambient Noise	The pre-existing sound environment of a location, before the introduction of, or in absence of, noise from a specific source which also affects the sound environment of that location.
Ambient Sound Level	Background sound level: the sound level that is present in the acoustic environment of a defined area. Ambient sound can include sources from transportation equipment, animals and nature.
Anchor Ice	A sheet of ice that adheres on the bottom of streams or channels when water flows on top of it.
Anion	A negatively charged ion.
Anthropogenic	Pertaining to the influence of human activities.
Aquiclude	An impermeable stratum or material that acts as a barrier to the flow of groundwater.

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.
Aquitard	A material of very low permeability between aquifers.
ArcGIS	An integrated collection of Geographic Information System (GIS) software products for building a complete GIS. ArcGIS enables users to deploy GIS functionality wherever it is needed in desktops, servers, or custom applications; over the Web; or in the field.
Argillaceous	Applied to rocks or substances composed of clay minerals, or having a notable proportion of clay in their composition.
Artesian	A condition in a confined aquifer when the water level of a well that penetrates the unit is above the ground surface. A well drilled into such a unit would flow without requiring a pump.
Aspect	Aspect is the orientation of a slope by compass points and indicates if a slope is exposed to the north, south, east or west or any point between.
At Risk	Any species known to be 'At Risk' after formal detailed status assessment and designation as 'Endangered' or 'Threatened' in Alberta.
Attenuation (Noise)	The process by which a compound is reduced in concentration over time, through adsorption, degradation, dilution and/or transformation. A reduction or diminishing of noise level.
B Horizon	A subsoil horizon characterized by one of: (1) an enrichment of clay, iron and aluminum, or humus (Bt or Bf); (2) a prismatic or columnar structure that exhibits pronounced coatings or stainings associated with significant amounts exchangeable sodium (Bn or Bnt); (3) an alteration by hydrolysis, reduction or oxidation to give a change of colour or structure from the horizons above or below, or both (Bm).
Background	An area not influenced by chemicals released from the site under evaluation.
Bankfull Depth	The maximum depth of a channel within a riffle segment when flowing at a bank-full discharge.

Bankfull Width	The width of the stream, measured at the water surface elevation corresponding to the bankfull discharge. For undisturbed streams with a wide floodplain, this is equivalent to channel width.
Basal Water Sands	A water-saturated sand unit occurring at the lowest portion of a stratigraphic unit.
Base Cation	An alkali or alkaline earth metal cation (Ca2+, Mg2+, K+, Na+).
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Basic Sound Level	The allowable sound level at a residential location, as defined by the current Alberta Energy and Utilities Board (EUB) Directive 038 with the inclusion of industrial presence based upon dwelling unit density and proximity to transportation noise sources.
Basin	A geographic area drained by a single major stream; consists of a drainage system comprised of streams and often natural or man-made lakes.
Bed Slope	The inclination of the river channel bottom.
Bedrock	The body of rock that underlies gravel, soil or other surficial material.
Benthic Invertebrates	Invertebrate organisms living at, in or in association with the bottom (benthic) substrate of lakes, ponds and streams.
Berm	Containment wall or barrier, usually constructed from clay, but can also be cement or other man-made, impermeable material (also called dikes).
Bins	Sub-divisions of wildlife Resource Selection Function (RSF) model output values.
Bioconcentration	A process where there is a net accumulation of a chemical directly from an exposure medium into 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.

Biodiversity Ranking	The relative contribution of an ecosite phase/wetlands type to the overall biological diversity of an area.
Biotic	The living organisms in an ecosystem.
Bioturbation	The disruption and mixing of sand and mud by animals such as worms, that live at or near the sediment water interface. Bioturbation is sometimes an indicator of the salinity of the water body that the sediment was deposited in.
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.
Boreholes	A hole advanced into the ground by means of a drilling rig.
Borrow Pit	A bank or pit from which sand or clay is taken for use in filling or embanking. Often used in the construction of roads.
Bowen Ratio	The ratio of sensible heat flux to latent heat flux.
Brackish Water	See Saline Water.
Brine	Water that contains high concentrations of soluble salts with a mineralization greater than 100,000 mg/L total dissolved solids.

Brown-Water System	Freshwaters with elevated colour and dissolved organic carbon concentrations.
Brunisolic Soil	An order of soils whose horizons are developed sufficiently to exclude the soils from the Regosolic order, but that lack the degrees or kinds of horizon development specified for soils of the other orders. These soils, which occur under a wide variety of climatic and vegetative conditions, all have Bm or Btj horizons.
Bryophyte	A member of the plant order Bryophyta, including the mosses, liverworts, and hornworts.
Buffer	A transition zone between areas managed for different objectives.
Buffer Zone	The area of land between the project footprint and Local Study Area boundaries.
Buffering Capacity	The ability of a system to accept acids without the pH changing appreciably.
Calendar-day	Stream-day multiplied by a service factor for planned and unplanned downtime. Production rate based on operating 365 day per year.
CALPUFF	A non-steady Lagrangian Gaussian Puff Model containing modules for complex terrain effects, overwater transport interaction effects, building downwash, wet and dry removal, and simple chemical transformation.
Canopy	An overhanging cover, shelter or shade. The tallest layer of vegetation in an area.
Canopy Disturbance	An opening in the forest canopy, from natural or unnatural causes.
Capability (land)	An evaluation of land performance that focuses on the degree and nature of limitation imposed by the physical characteristics of the land unit on a certain use, assuming a management system.
Carbonaceous Biochcemical Oxygen Demand (CBOD)	Carbonaceous biochemical oxygen demand is a measure of the quantity of oxygen consumed by microorganisms during the breakdown of organic molecules such a cellulose and sugars into carbon dioxide and water.
Carcinogen	An agent that is reactive or toxic enough to act directly to cause cancer.

Carnivore	Any order of mammals that feed chiefly on flesh or other animal matter rather than plants.
Catchment Area	The area of land from which water finds its way into a particular watercourse, lake or reservoir (Also termed “catch basin” or “watershed.”
Cation	A positively charged ion.
Channel	The bed of a stream or river.
Channel Regime	The morphological characteristics, including cross-section, longitudal slope and sinuosity, of a watercourse that is in long-term equilibrium.
Chi-Square Analysis	A statistical test to determine if the patterns exhibited by data could have been produced by chance.
Chlorophyll a	A green photo-sensitive pigment that is essential for the conversion of inorganic carbon (e.g., carbon dioxide) and water into organic carbon (e.g., sugar).
Chlorosis	A yellowing of leaf tissue due to a lack of chlorophyll, generally caused by poor drainage, damaged roots, compacted roots, high alkalinity or nutrient deficiencies in the plant.
Class Area	The area of a particular habitat quality class within the study area.
Closed Canopy	Assemblages of trees with tops sufficiently close to each other that there is very little visible sky from the position of the forest floor.
Closure	The point after shutdown of operations when regulatory certification is received and the area is returned to the Crown.
Coefficient of Variation	Standardized index of the variability of a value relative to the mean value.
Colluvial	A heterogeneous mixture of material that as a result of gravitational action has moved down a slope and settled at its base.
Community	Plant or animal species living in close association or interacting as a unit.
Complex Structure	A stand of trees with a high variation in heights but with no distinct tree layers.

Concentration	Quantifiable amount of a substance in environmental media.
Concordance Table	A table that serves as a cross-reference between regulated requirements and location of documented compliance.
Conductivity	A measure of the capacity of water to conduct an electrical current.
Configuration	The location and arrangement of landscape elements.
Coniferous	These are cone-bearing trees with no true flower (e.g., white spruce, black spruce, balsam fir, jack pine and tamarack).
Connectivity	A measure of how connected or spatially continuous a corridor or matrix is.
Consolidated Frequency Analysis (CFA)	A computer program for deriving flood flow frequencies.
Contaminants	A general term referring to any chemical compound added to a receiving environment in excess of natural concentrations. The term includes chemicals or effects not generally regarded as “toxic”, such as nutrients, colour and salts.
Contouring	Process of shaping the land surface to fit the form of the surrounding land.
Corridor	A travel route allowing animals to migrate from one faunal region to another.
Criteria (water quality)	The standards against which water quality is measured.
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.
Cross Stratification	Inclined sedimentary beds that form in sand dunes.
Crown Closure	The ground cover area covered by a vertical projection of the tree crowns onto the ground for each identified storey.
Crust Lichen	Lichen with a hard upper surface and attached closely to the substrate.

Cumulative Effects	The effects of one project with consideration of current conditions, other existing projects, other approved projects and typically, other planned projects.
Cumulative Environmental Management Association (CEMA)	An association of oil sands industry, other industry, regional community representatives, regulatory agencies and other stakeholders designed to develop systems to manage cumulative effects associated with developments in the Oil Sands Region.
Cutblock	Previously forested area that has been harvested for timber and is presently regenerating at various stages of regrowth.
Cutline	A cleared right-of-way, often used in forestry or seismic work.
dBA	A decibel value which has been A-weighted, or filtered to match the response of the human ear.
dBC	A decibel value which has been C-weighted, or filtered to highlight low frequency content.
Decibel (dB)	A decibel value which has been A-weighted, or filtered to match the response of the human ear.
Deciduous	Tree species that lose their leaves at the end of the growing season.
Decommissioning	The act of taking a processing plant or facility out of service and isolating equipment to prepare for routine maintenance work, suspending or abandoning.
Department of Fisheries and Oceans (DFO) (now Fisheries and Oceans Canada)	Federal department responsible for policies and programs in support of Canada's economic, ecological and scientific interests in oceans and inland waters; for the conservation and sustainable utilization of Canada's fisheries resources in marine and inland waters.
Deposit	Material left in a new position by a natural transporting agent such as water, wind, ice or gravity, or by the activity of man.
Depressurization	The process of reducing the pressure in geological formation.
Detection Limit	The lowest concentration that can be reported by an analytical laboratory with a specified confidence level.
Detrended Correspondence Analysis (DCA)	An ordination technique used to visually determine species and site relationships.

Development Area	Any area altered to an unnatural state. This represents all land and water areas included within activities associated with the development of oil sands leases.
Diameter at Breast Height (DBH)	The diameter of a tree 1.37 m above the ground surface.
Dilbit	Diluted bitumen created by adding lighter fraction hydrocarbons to bitumen.
Diluent	A light liquid hydrocarbon added to bitumen to lower viscosity and density. The thinning agent is used by the oil sands to make heavy oil more fluid so it can be transported.
Discharge	In a stream or river, the volume of water that flows past a given point in a unit of time (i.e., m^3/s).
Dispersion Model	A set of mathematical relationships used to describe the rise and subsequent dispersion of a plume as it is transported by the wind. These relationships are given coded names (e.g., SCREEN3 and CALPUFF) and are computer modeled.
Dissolved Organic Carbon (DOC)	The dissolved portion of organic carbon water; made up of humic substances and partly degraded plant and animal materials.
Dissolved Oxygen (DO)	Measurement of the concentration of dissolved (gaseous) oxygen in the water, usually expressed in milligrams per litre (mg/L).
Disturbance	An event that causes a sudden change from the existing pattern, structure and/or composition in an ecological system or habitat.
Diversity	The variety, distribution and abundance of different plant and animal communities and species within an area.
Dose	A measure of integral exposure. Examples include: (1) the amount of chemical ingested; (2) the amount of a chemical taken up; and (3) the product of ambient exposure concentration and the duration of exposure.
Dose Response	The quantitative relationship between exposure of an organism to a chemical and the extent of the adverse effect resulting from that exposure.
Drake	A male duck.

Drawdown	A reduction in the height of the water table.
Drill Core	A cylinder of rock taken by a specialized drill bit similar to a hole saw, that can be analysed for various rock and fluid properties.
Echolocation	High frequency sounds (25 to 120 kHz) produced by bats that are beyond the range of human hearing (20 Hz to 25 kHz). These sounds are produced with great intensity. Echoes resulting from sound returning from objects in the bat's environment provide information to the bat.
Ecodistrict	A broad subdivision of the landscape based on differences in landscape pattern, topography and dominant soils.
Ecological Area	As part of the hierarchical classification system outlined in the Field Guide to Ecosites of Northern Alberta, a broad climatic region within the green zone of Alberta.
Ecological Land Classification (ELC)	A means of classifying landscapes by integrating landforms, soils and vegetation components in a hierarchical manner.
Ecosite	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.
Ecosite Phase	A subdivision of the ecosite based on the dominant tree species in the canopy. On some sites where the tree canopy is lacking, the tallest structural vegetation layer determines the ecosite phase.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. 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.
Edge	Where different plant communities meet in space on a landscape; and where plant communities meet a disturbance. An outer band of a plant community that usually has an environment significantly different from the interior of the plant community.

Effluent	Stream of water discharging from a source.
Electrical Conductivity	The capability of a solution to transmit an electrical current. A capability closely related to the concentration of salts in soils.
Electrofishing	A 'live' fish capture technique in which negative (anode) and positive (cathode) electrodes are placed in the water and an electrical current is passed between the electrodes. Fish are attracted (galvano-taxis) to the anode and become stunned (galvano-narcosis) by the current, allowing fish to be collected, measured and released.
Energy Resources Conservation Board (ERCB)	An independent, quasi-judicial agency of the Government of Alberta. The purpose of the ERCB 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.
Endangered	A species facing immediate extinction or extirpation.
Entrenchment Ratio	The ratio of the width of the flood-prone area to the surface width of the bankfull channel, which is used to describe the degree of vertical containment of a river channel.
Environmental Effect	Any change that may cause positive or negative effects to land, air, water, living organisms (including people), cultural, historical or archeological resources.
Environmental Impact	The net change, positive or negative, to land, air, water, living organisms (including people), cultural, historical or archeological resources.
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)**	Provincial act created to support and promote the protection, enhancement and wise use of the environment.
Environmental Setting	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Eolian	A designation of rocks and soils whose constituents have been carried and laid down by wind.

Ephemeral	A phenomenon or feature that lasts only a short time (e.g., an ephemeral stream is only present for short periods during the year).
Epilimnetic	Localized in the surface layer of a waterbody.
Epilimnion	A freshwater zone of relatively warm water in which mixing occurs as a result of wind action and convection currents.
Epiphyte	A plant that grows upon another plant, but is neither parasitic on it nor rooted in the ground.
Equivalent Land Capability	The ability of land to support various land uses after reclamation is similar to the ability that existed prior to any activity on the land, but the ability to support individual land uses will not necessarily be equal after reclamation.
Ericaceous	Plant species belonging to the heath family (Ericaceae) and typically prefer acid soil.
Erosion	The process by which material, such as rock or soil, is worn away or removed by wind or water.
Escarpment	A cliff or steep slope at the edge of an upland area. The steep face of a river valley.
Estuarine	Formed or deposited in an estuary; estuarine muds: or growing in, inhabiting, or found in an estuary; an estuarine fauna.
Euphotic	The upper surface layer of a body of water where sufficient light penetrates to allow photosynthesis to occur.
Eutrophic	The nutrient-rich status (amount of nitrogen, phosphorus and potassium) of an ecosystem.
Eutrophication	Excessive growth of algae or other primary producers in a stream, lake or wetlands as a result of large amounts of nutrient ions, especially phosphate or nitrate
Evaporation	The process by which water is changed from a liquid to a vapour.
Evaporation, Potential	The maximum amount of water that can be evaporated from a surface (e.g., ground, vegetation) if surface moisture is not limited.
Evaporite	A sediment that is deposited from aqueous solution as a result of extensive or total evaporation.

Evapotranspiration	The process by which water is transmitted as a vapor to the atmosphere as the result of evaporation from any surface and transpiration from plants.
Existing and Approved Case	The Environmental Impact Assessment case that includes existing environmental conditions as well as existing and approved projects or activities.
Facies	A distinctive group of characteristics that distinguish one group from another within a stratigraphic unit; e.g. contrasting river-channel facies and overbank-flood-plain facies in alluvial valley fills.
Fauna	An association of animals living in a particular place or at a particular time.
Fen	A peat-forming wetland. Fens are defined from other peat wetlands by the source of water, which is contributed primarily by flowing surface or underground spring water versus solely from rain (such as bogs). As such, they tend to be more mineral rich than other peat wetlands. Fens can be dominated by grasses, shrubs or trees.
Field Facilities	The surface equipment and pipelines required to deliver steam to the wells and transport fluids to the central plant.
Fish Habitat (*Fisheries Act*)	Spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes.
Flark	Wet and sparsely vegetated parts of patterned fens.
Fluvial	Relating to a stream or river.
Fluvial Sediment	Sediment generally consisting of gravel and sand with a minor fraction of silt and rarely clay. The gravels are typically rounded and contain interstitial sand.
Foliose	Having a leaf-like thallus loosely attached to a surface, as certain lichens.
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).

Forb	A broad-leaved herb that is not a grass.
Forest	A growth of trees and underbrush covering a tract of land.
Forest Cover Type	Primary stand groupings based on the percent composition of coniferous or deciduous species. Forest cover type can be deciduous, coniferous or mixedwood. Also, regenerating and selective harvest stands are included as a forest cover type.
Forest Fragmentation	The change in the forest landscape, from extensive and continuous forests.
Forest Productivity	A measure of forest growth based on the volume of wood fibre added to the landbase annually (i.e., mean annual increment) or the rate at which trees grow in height over a given period of time as defined by a timber productivity rating or site index value.
Forest Succession	see Succession.
Formation	A geologic unit of distinct rock types that is large enough in scale to allow its mapping over a region.
Fossiliferous	Contains fossils or the remains of plants and animals.
Fragmentation	The process of reducing size and connectivity of stands of trees that compose a forest.
FRAGSTATS	A spatial pattern analysis software program used to quantify the areal extent and spatial configuration of patches within a landscape. The analysis is done using categorical spatial data (e.g., plant communities).
Frequency Analysis	A statistical procedure involved in interpreting the past record of a hydrometeorological event to occurrences of that event in the future.
Freshet	A flood resulting from a spring thaw resulting from snow and ice melts in rivers.
Fry	The early stage of development for the fish from hatching until it is one year old.
Fuel Gas	Gas used as fuel for the various pieces of equipment. Fuel gas can be purchased gas or a mixture of purchased gas and treated produced gas.

Fugitive Emissions	Substances emitted from any source except those from stacks and vents. Typical sources include gaseous leakage from valves, flanges, drains, volatilization from ponds and lagoons, and open doors and windows. Typical particulate sources include bulk storage areas, open conveyors, construction areas or plant roads.
Furbearer	Mammals that have traditionally been trapped or hunted for their fur.
G Test	A statistical test which tests for a significant difference between sampled and expected frequencies of occurrence. Otherwise known as a likelihood ratio test.
Gathering System	The pipelines and other equipment needed to transport oil, gas or both from wells to a central point.
Genetic Diversity	The range of possible genetic characteristics found within a species and amongst different species (e.g., variations in hair colour, eye colour and height in humans).
Geographic Information System (GIS)	Computer software designed to develop, manage, analyze and display spatially referenced data.
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 which deals with the form of the earth, the general configurations of its surface and the changes that take place in the evolution of landforms.
Glacial Till	Unsorted and unstratified heterogeneous mixture of clay, silt, sand, gravel and boulders deposited directly by a glacier without subsequent reworking by water from the glacier.
Glaciofluvial	Sediments or landforms produced by melt waters originating from glaciers or ice sheets. Glaciofluvial deposits commonly contain rounded cobbles arranged in bedded layers.
Glacolacustrine	Relating to the lakes that formed at the edge of glaciers as the glaciers receded. Glaciolacustrine sediments are commonly laminar deposits of fine sand, silt and clay.
Gleysolic Soil	A great group of soils in the Gleysolic order. A Gleysol has a thin (less than 8 cm) Ah horizon underlain by mottled grey or brownish grey material, or it has no Ah horizon.

Graminoid	Grasses and grass-like plants such as sedges and rushes.
Graupel	Precipitation that forms when supercooled droplets of water condense on a snowflake.
Groundtruth	Visiting locations in the field to confirm or correct information produced from remote sources such as interpreted aerial photographs or classified satellite imagery.
Groundwater	That part of the subsurface water that occurs beneath the water table, in soils and geologic formations that are fully saturated.
Groundwater Level	The level below which the rock and subsoil, to unknown depths, are saturated.
Groundwater Mounding	An area of a groundwater system featuring an increased groundwater surface elevation above the baseline condition for that area.
Groundwater Recharge	Water that enters the saturated zone by a downward movement through soil and contributes to the overall volume of groundwater.
Groundwater Velocity	The speed at which groundwater advances through the ground; the average linear velocity of the groundwater.
Guild	A set of co-existing species that share a common resource.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Habitat Fragmentation	Reduction of extensive, continuous tracts of habitat into smaller, more isolated patches.
Habitat Generalist	Wildlife species that can survive and reproduce in a variety of habitat types (e.g., red-backed vole).
Hardness	Measure of the calcium and magnesium concentrations in water.
Hazard	A condition with the potential for causing an undesirable consequence.
Hazardous Waste	Any waste material that presents a potential for unwanted consequences to people, property and the environment.

Head	The energy, either kinetic or potential, possessed by each unit weight of a liquid; expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed.
Herb	A vascular plant (forb or graminoid) without a woody stem.
Heterogeneity	Consisting of parts that are unlike each other. For example, the variety and abundance of ecological units (e.g., ecosite phases and wetlands types) comprising a landscape mosaic.
Historical Resources Impact Assessment (HRIA)	A review of the effects that a proposed development will have on the local and regional historic and prehistoric heritage of an area.
Home Range	The area that an animal traverses as part of its annual travel patterns.
Hydraulic Conductivity	Is a measure of how easy water can flow through a porous material.
Hydraulic Head	The elevation, with respect to a specified reference level, at which water stands in a piezometer (a pipe in the ground used to measure water elevations/or a small diameter observation well) connected to the point in question in the soil. Its definition can be extended to soil above the water table if the piezometer is replaced by a tensiometer (instrument used to measure moisture content of soil). The hydraulic head in systems under atmospheric pressure may be identified with a potential expressed in terms of the height of a water column. More specifically, it can be identified with the sum of gravitational and capillary potentials, and may be termed the hydraulic potential.
Hydric	Soil moisture conditions where water is removed so slowly that the water table is at or above the soil surface all year.
Hydrogeology	The study of the factors that deal with subsurface water (groundwater) and the related geologic interactions with surface water.
Hydrology	The science of waters of the earth, their occurrence, distribution, and circulation; their physical and chemical properties; and their reaction with the environment, including living beings.
Hydrometric Station	A station where measurement of hydrological parameters is performed.

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.
Hygric	Soil moisture conditions where water is removed slowly enough to keep the soil wet for most of the growing season. Permanent seepage and mottling are present and possibly weak gleying.
Hypereutrophic	Trophic state classification for lakes characterized by very high productivity and nutrient inputs (particularly total phosphorus).
Hypolimnion	The deep, cold layer of a lake lying below the metalimnion (thermocline) during the time a lake is normally stratified.
Inclined Heterolithic Stratification	Inclined beds of alternating mud and sand that are deposited on the sides of channel bars.
Infaunal	Animals living within the sediment.
In-Situ	Latin for "in place". As used here, refers to methods of extracting deep deposits of oil sands using wells to recover the resources with less impact to the land, air and water than for oil sands mining.
Interbedded Sand and Mud	Alternating beds of sand and mud deposited during times of strong water flow and negligble water flow.
Internal Lawn	Wet depresssional areas within bog or fen wetlands types that are absent of trees and contain species adapted to wetter conditions than the surrounding treed habitat.
Invasive Species	A species that has moved into an ecosystem and reproduced so successfully that it has displaced the original structure of the community.
Isopach Map	A geological map of subsurface strata showing the various thicknesses of a given formation underlying an area.
Isopleth	A line on a map connecting places sharing the same parameter (e.g., ground-level concentration)
Key Indicator Resources (KIRs)	Environmental attributes or components identified as a result of a social scoping exercise as having legal, scientific, cultural, economic or aesthetic value.

Keystone Species	A species that is of particular importance to community integrity and function, without which significant changes to the community would occur.
Lacustrine	Sediment that have been transported or deposited by water or wave action. Generally consisting of stratified sand, silt or clay deposited on a lake bed or moderately well sorted and stratified sand and coarser material.
Land Capability	The ability of the land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation.
Land Capability Class	A land capability class assigned to an area according to the criteria outlined in Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition, as amended.
Land Classification	The classification of specific bodies of land according to their characteristics or their capabilities of use.
Land Cover Class	A vegetated or non-vegetated map unit defined here at the regional study area level and classified from LANDSAT 5 satellite imagery.
Land Status Automated System (LSAS)	An online government database containing Alberta Surface Public Land and Crown Mineral dispositions and activities. Includes information about land restrictions and reservations.
LANDSAT 5	A specific satellite or series of satellites used for earth resource remote sensing. Satellite data can be converted to visual images for resource analysis and planning.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular “focal” or “target” habitat patch is embedded.
Landscape Structure	The spatial relations among a landscape’s component parts including composition; the presence and amount of each patch type without being spatially explicit; and landscape configuration, the physical distribution or spatial character of patches within a landscape.
Leaf Area Index (LAI)	The ratio of leaf area to soil surface area.

Leakance	A property of a leaky layer. Expressed as K' divided by b', where K' refers to the hydraulic conductivity of the leaky layer confirming an aquifer in units of length/time and b' refers to the thickness of the leaky layer in units of length.
Lichen	Any complex organism of the group Lichenes, composed of a fungus in symbiotic union with an alga and having a greenish, gray, yellow, brown, or blackish thallus that grows in leaflike, crustlike, or branching forms on rocks, trees, etc.
Lift Gas	Gas injected into the reservoir to help it flow from the well.
Lignin	A complex polymer occurring in plant cell walls making the plant rigid.
Linear Corridor	Roads, seismic lines, pipelines and electrical transmission lines, or other long, narrow disturbances.
Listed Species	Species that are provincially or federally identified as potential species of concern.
Lithic	Consolidated bedrock within the control section below a depth of 10 cm. The upper surface of a lithic layer is a lithic contact.
Lithofacies	A rock or sediment with specific lithologic or textural characteristics.
Littoral Zone	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.
Lognormal	Of, relating to, or being a logarithmic function with a normal distribution.
Long Range Sustained Yield Average (LRSYA)	The sums of Mean Annual Increment (MAI) for all forest cover types in a study area. LRSYA is an estimate for the sustained yield or expected annual growth of the coniferous and deciduous fibre in a study area.

Low Frequency Noise (LFN)	Where a clear tone is present below and inclusive of 250 Hz. Low frequency noise can be determined by subtracting the overall C-weighted from the overall A-weighted sound level, or as the overall C-weighted sound level by itself.
Lowest Observed Adverse Effect Level (LOAEL)	In toxicity testing, it is the lowest concentration at which adverse effects on the measurement end point are observed.
Lowland Areas	Areas with ground slopes of less than 0.5% and typically poorly drained.
Luvisol	An order of soils that have eluvial (Ae) horizons, and illuvial (Bt) horizons in which silicate clay is the main accumulation product. The soils developed under forest or forest-grassland transition in a moderafe to cool climate.
Macrophytes	Plants large enough to be seen by the unaided eye. Aquatic macrophytes are plants that live in or in close proximity to water.
Main Canopy	A well-defined, uppermost layer of trees within a forest.
Make-Up Water	The water required to supplement recycled produced water for steam production.
Marsh	A non-peat-forming, nutrient-rich wetlands characterized by frequent flooding and fluctuating water levels.
Mature Forest	A forest with a multi-layered, multi-species canopy dominated by large overstorey trees and accumulations of downed woody debris.
May be at Risk	Any species that ‘May be at Risk’ of extinction or extirpation and is therefore a candidate for detailed risk assessment.
Mean Patch Size	The average size of habitat patches within the study area.
Meander	A randomized search pattern used in rare plant surveys to cover the range in micro-habitat variation within a larger ecosystem unit.
Media	The physical form of the environmental sample under study (e.g., soil, water, air).
Merchantable Timber	A forest area with potential to be harvested for production of lumber/timber or wood pulp. Forests with a timber productivity rating of moderate to good.

Mesic	A moderate soil moisture regime value whereby water is removed somewhat slowly in relation to supply. Available soil water reflects climatic inputs.
Mesotrophic	Trophic state classification for lakes characterized by moderate productivity and nutrient inputs (particularly total phosphorus).
Meteoric Water	That which occurs in or is derived from the atmosphere.
Micro-Habitat	A small-scale surface in the landscape that has its own unique surface properties different from surrounding surfaces.
Mineral Soil	Soils containing low levels of organic matter. Soils that have evolved on fluvial, glaciofluvial, lacustrine and morainal parent material.
Mitigation	The elimination, reduction or control of the adverse environmental effects of the project.
Mitigative Measures	Procedural, locational and timing constraints and methods employed to address project-related impacts.
Mixedwood	A terrestrial forest type that is an assemblage of both deciduous and coniferous tree species.
Mixing Height	The depth of surface layer in which atmospheric mixing of emissions occurs.
Modelling	A simplified representation of a relationship or system of relationships. Modelling involves calculation techniques used to make quantitative estimates of an output parameter based on its relationship to input parameters.
Moisture Regime	The relative moisture supply at a site available for plant growth.
Monitoring	Repetitive measurement of specific environmental phenomena to document change primarily for the purpose of: a) testing impact hypotheses and predictions and b) testing mitigative measures.
Moraine	Sediment generally consisting of well compacted material that is nonstratified and contains a heterogeneous mixture of particle sizes, often in a mixture of sand, silt, and clay that has been transported beneath, beside, on, within and in front of a glacier and not modified by any intermediate agent.

Multistorey	Forest stands where two or three storeys exist and each storey is significant, clearly observable and evenly distributed.
Muskeg	A soil type comprised primarily of organic matter. Also known as bog peat prevalent in northern Canada.
Native Plant	Plant species that naturally occur in a given area.
Native Species	Species that are known to be historically present in a given area.
Natural Region	The highest level in Alberta's ecological classification hierarchy; defined broadly on the basis of climate, topography, landforms and soil.
Natural Subregion	A division of the natural regions of Alberta. Areas within a natural subregion have a similar climatic regime, which is characterized by modal vegetation distinct for that subregion.
Necrosis	Death of cells and living tissue.
Nitrophillic	Nitrogen-loving plant species.
No Observed Adverse Effect Level (NOAEL)	In toxicity testing, it is the highest concentration at which no adverse effects on the measurement end point are observed.
Non-Condensable Gas	A substance that exists in a gaseous form under reservoir pressure and temperature.
Non-Native Plant	An introduced plant that has been brought over from another ecosystem by man and has established itself within its new environment.
Non-Sport Fish	Large fish which is not caught for food or sport (e.g., longnose sucker, white sucker).
Non-Vascular Plant	Plants that do not possess conductive tissues (e.g., veins) for the transport of water and food.
NO_x	A measure of the oxides of nitrogen comprised of nitric oxide (NO) and nitrogen dioxide (NO_2).
Nutrient Regime	The relative supply of nutrients available for plant growth at a given site.

Nutrients	Substances (elements or compounds), such as nitrogen or phosphorus, that are necessary for the growth and development of plants and animals.
Oil Sands	A sand deposit containing a heavy hydrocarbon (bitumen) in the intergranular pore space of sands and fine grained particles.
Oil Sands Region	The Oil Sands Region includes the Fort McMurray – Athabasca Oil Sands Subregional Integrated Resource Plan (IRP), the Lakeland Subregional IRP and the Cold Lake – Beaver River Subregional IRP.
Old Growth Forest	An ecosystem distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species, composition, and ecosystem function. Old growth forests are those forested areas where the annual growth equals annual losses. Mean annual increment of timber volume equals zero. They can be defined as those stands that are self-regenerating (i.e., having a specific structure that is maintained).
Oligotrophic	Trophic state classification for lakes characterized by low productivity and low nutrient inputs (particularly total phosphorus).
Ombrogeneous Bog	A mineral-poor, acid, peat-forming plant community that derives all its water and dissolved nutrients, from rainfall.
Ombrotrophic	Wetlands which receive all water and nutrients from direct precipitation.
Organic Soil	Soils containing high percentages of organic matter (fibric and humic inclusions).
Organics	Organic compounds (organics) include chemicals consisting of chains or rings of carbon atoms, such as hydrocarbons, phenols, PAHs and naphthenic acids.
Orthophoto	A digital image of an aerial photograph.
Outlier	A data point that falls outside of the statistical distribution defined by the mean and standard deviation.

Outwash	A glaciofluvial sediment that is deposited by meltwater streams emanating from a glacier.
Overburden	Material below the soil profile and above the bituminous sand.
Overstorey	Those trees that form the upper canopy in a multi-layered forest.
Overwintering Habitat	Habitat used during the winter as a refuge and for feeding.
Ozone (O_3)	Ozone is 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.
Parasequence	a series of related layers of sediment bounded by shales that were deposited in deeper water.
Patch	An area that is different from the area around it (e.g., vegetation types, non-forested areas). This term is used to recognize that most ecosystems are not homogeneous, but rather exist as a group of patches or ecological islands.
Patterned Fen	Peatlands that display a distinctive pattern due to alterations between open wet areas (flarks) and drier shrubby to wooded areas (strings).
Peat	A material composed almost entirely of organic matter from the partial decomposition of plants growing in wet conditions.
Peatland Complex	Within a given area, a mixture of bog and fen wetlands types have formed usually as a result of variation in groundwater flow regimes.
Peatlands	Areas where there is an accumulation of peat material at least 40 cm thick. These are represented by bog and fen wetlands types.
Permafrost	Permanently frozen ground (subsoil).
Permeability	The capacity of porous rock, sediment, soil or a medium for transmitting a fluid, generally measured in Darcy [D] or millidarcy [mD].
Permissible Sound Level	The allowable overall A-weighted sound level of noise from energy industry sources, as specified by the EUB Directive 038, which may contribute to the sound environment of a residential location.

Petrophysical Well Logs	Charts produced by measuring various physical properties of rocks or sediments in a well bore.
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.
Phosphorus	The key nutrient influencing plant growth in lakes; total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.
Photochemistry	The reaction that proceeds with the absorption of light.
Phytotoxic	Toxic or poisonous to plants or plant tissue.
Phytotoxic Metals	Metals in concentrations toxic to plants.
Piezometer	A pipe in the ground in which the elevation of water levels can be measured, or a small diameter observation well.
Pixel	The basic unit of digital imagery data. Shortened from “picture element”. The intensity of each pixel corresponds to the average “brightness” measured electronically by the sensor.
Planned Development Case (PDC)	The Planned Development Case includes the Project Case components and planned developments that have been publicly disclosed at least six months prior to submission of the Environmental Impact Assessment.
Plant Community	A group of interacting plant species that exist within a defined space and time.
Plant Community Type	As part of the hierarchical classification system outlined in the Field Guide to Ecosites of Northern Alberta, this ecological unit represents the lowest level taxonomic unit of the ecosite classification system. These units are subdivisions of an ecosite phase based on differences in understorey species composition.
PM_{10}	Airborne particulate matter with a mean diameter less than 10 µm (microns) in diameter. This represents the fraction of airborne particles that can be inhaled into the upper respiratory tract.

$PM_{2.5}$	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)	A chemical by-product of petroleum-related industry. Aromatics are considered to be highly toxic components of petroleum products. PAHs, many of which are potential carcinogens, are composed of at least two fused benzene rings. Toxicity increases along with molecular size and degree of alkylation of the aromatic nucleus.
Polygon	The spatial area delineated on a map to define one feature unit (e.g., one type of ecosite phase).
Population	A collection of individuals of the same species that potentially interbreed.
Population Sink	A habitat within which reproductive and mortality rates should result in population declines. However, populations may be maintained in such habitat by immigration from nearby habitats that are more productive. The term was introduced by Pulliam (1988).
Pore	The void space between sediment particles.
Porewater	Water filling the void space between sediment particles.
Porosity	The percentage of the bulk volume of a rock or soil that is occupied by pores, whether isolated or connected.
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.
Produced Gas	Gas co-produced with the bitumen.
Productive Forest	Forests on lands with a capability rating of equal to or greater than three and stocked with enough trees to meet the standards of a merchantable forest.
Progradation	When a shoreline moves seaward as the result in increased sediment supply or a drop in sea level.
Project Case	The EIA case including the project that is the subject of the application, existing environmental conditions, and existing and approved projects or activities.

Puff Splitting	As the effluent puff is carried away from the source by the wind, it will disperse and break apart into smaller puffs, which in turn will break apart into even smaller puffs.
Rare Plant Community	Plant communities that are described as unusual, uncommon, of limited extent or encountered infrequently.
Rare Plant Potential	A ranking system used to determine and map the likelihood of finding rare plants or the relative abundance of rare plant species among different vegetation types or land cover classes within the landscape.
Rare Plants	A native plant species found in restricted areas, at the edge of its range or in low numbers within a province, state, territory or country.
Raster	A graphic structure where the data is divided into cells on a grid. An example would be a computer screen where an image is represented by horizontal lines of coloured pixels. Shapes are represented by cells of the same colour or content adjacent to each other.
Rating Curve	In hydrology, it typically refers to a curve showing the relation between the discharge of a river or stream and the water level in the stream.
Recharge /Discharge Area	Areas that either contribute (recharge) or take away (discharge) to/from the overall volume of groundwater in an aquifer.
Reclamation	The restoration of disturbed land or wasteland to a state of useful capability. Reclamation is the initiation of the process that leads to a sustainable landscape, including the construction of stable landforms, drainage systems, wetlands, soil reconstruction and addition of nutrients. This provides the basis for natural succession to mature ecosystems suitable for a variety of end uses.
Reclamation Certificate	A certificate issued by an Alberta Environment, Conservation and Reclamation Inspector, signifying that the terms and conditions of a conservation and reclamation approval have been complied with.

Reference Concentration (RfC)	For a specific chemical that is conceptually equivalent to an air quality objective, and is expressed in µg/m^3. It is an exposure limit that is established for chemicals which are locally acting (e.g., irritant chemicals), whose toxicity is dependent solely on the air concentration and not on the total internal dose received via multiple exposure pathways.
Regional Aquatics Monitoring Program (RAMP)	The RAMP was established to determine, evaluate and communicate the state of the aquatic environment in the Athabasca Oil Sands Region.
Regional Issues Working Group (RIWG)	A group that works to promote the responsible, sustainable development of resources within the Regional Municipality of Wood Buffalo.
Regional Study Area (RSA)	Defines the spatial extent related to the cumulative effects resulting from the project and other regional developments.
Regional Sustainable Development Strategy (RSDS)	A regulatory framework for balancing development of Alberta's oil sands resources with protection of the environment.
Regosol	The only great group in the Regosolic order. The soils in the group have insufficient horizon development to meet the requirements of the other orders.
Relative Abundance	The proportional representation of a species in a sample or a community.
Remediation	The process of planning for, investigating and potentially managing or removing the effects of chemical substances on the environment, including soil or groundwater effects.
Replicate	Duplicate analyses of an individual sample. Replicate analyses are used for measuring precision in quality control.
Resistivity	A measure of how much a material resists the flow of electricity.
Richness	The number of species in a biological community (e.g., habitat).
Rights-of-way	The strip of land over which a power line, railway line, road, etc., extends
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.

Risk	The possibility of injury, loss or environmental incident created by a hazard. The significance of the risk is determined by the probability on an unwanted incident and the severity of the consequences.
Rough Broken	An area having steep slopes and many intermittent drainage channels, but usually covered with vegetation.
Runoff	The portion of water from rain and snow that does not infiltrate into the ground, or evaporate.
Saline Water	Water with total dissolved solids between 1,000 and 10,000 mg/L.
Scale	Level of spatial resolution.
Scavenging	Removal of a pollutant from the air through chemical or physical processes such as dry deposition or washout by precipitation
Secondary Canopy	A well-defined, layer of trees beneath the main canopy within a forest.
Secure	A species that is not 'At Risk', 'May be at Risk', or 'Sensitive'.
Sedge	Any plant of the genus Carex, perennial herbs, often growing in dense tufts in marshy places. They have triangular jointless stems, a spiked inflorescence and long grass-like leaves which are usually rough on the margins and midrib. There are several hundred species.
Sediment	Solid material that is transported by, suspended in, or deposited from water.
Sediment Yield	The amount of sediment transported by a stream system that may be measurable at a particular location. Usually expressed in volume or weight per unit of time.
Sedimentation	The process of the deposition of suspended particles carried by water, wastewater or other liquids, by gravity. It usually occurs through a reduction in the velocity of the liquid below the point which it can transport the suspended material.
Sensitive	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.

Sensory Disturbance	Visual, auditory, or olfactory stimulus which creates a negative response in wildlife species.
Sentinel Species	Species that can be used as an indicator of environmental conditions.
Shadow Population	The people who live in work camps, campgrounds or hotels in the Athabasca Oil Sands Region.
Shannon's Evenness Index (SHEI)	Distribution of area among or within patch types in the landscape.
Shoreface	The portion of the ocean or lake bottom that affected by wave action.
Shredder Insect	A herbivorous or detritivorous aquatic insect that chews or gorges vascular plants, decaying plant material or woody material as a food source.
Sink Habitat	A habitat within which reproductive and mortality rates should result in population declines. However, populations may be maintained in such habitat by immigration from nearby habitats that are more productive. The term was introduced by Pulliam (1988).
Sinuosity	The ratio of the thalweg length (i.e., the line connecting the deepest points along a stream) to valley length, for a specific reach of a river or stream system. This is, in essence, a ratio of the stream's actual "running" length to its down-gradient length.
Site Index	The average height of undamaged, dominant and co-dominant trees in a stand at a standard (reference) age that have been free-growing since reaching breast height.
Snag	A naturally occurring, standing dead or dying tree often missing a top or most of the smaller branches.
Soil Heat Flux	The soil heat flux constant is a function of the surface properties and is used to compute the flux of heat into the soil.
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.

Soil Nutrient	A chemical element or compound found in the soil that is essential for plant growth.
Soil Series	The basic unit of soil classification in the Canadian System of Soil Classification and consists of soils that are essentially alike in all major profile characteristics except the texture at the surface.
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/m2, which is radiation energy per second per unit area.
Sound Power	The rate of acoustic energy flow across a specified surface, or emitted by a specified sound source. Units W (Watt).
Spawning	The reproductive stage of adult fish which includes fertilization and deposition of eggs.
Special Concern (Vulnerable)	A species is of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Special Plant Community	Communities that are suspected to be rare or unique but are differentiated from known rare plant communities in that there is less information known about them, and currently, are not included on ANHIC's Preliminary Ecological Community Tracking and Watch List.
Species	A taxonomic grouping of genetically and morphologically similar individuals that actually or potentially interbreed and are reproductively isolated from all other such groups.
Species Abundance	The number of individuals of a particular species within a biological community (e.g., habitat).
Species Composition	The number and abundance of species found within a biological community.
Species Distribution	Where the various species in an ecosystem are found at any given time. Species distribution varies with season.
Species Diversity	A description of a biological community that includes both the number of different species and their relative abundance. Provides a measure of the variation in number of species in a region.
Species Richness	The number of different species occupying a given area.

Spectral Signature	The unique characteristics in solar reflectance of a particular land classification unit based upon multi-spectral satellite imagery.
Sphagnum	A genus of peat-forming moss.
Sport Fish	Large fish caught for food or sport (e.g., northern pike, Arctic grayling).
Stand	A group of trees occupying a specific area and sufficiently uniform in composition, age, arrangement and condition so that it is distinguished from trees in adjoining areas.
Stand Age	The number of years since a forest has been affected by a stand-replacing disturbance event (e.g., fire or logging) and has since been regenerating.
Stand Density	The relative closure of a forest canopy.
Stand Structure	The various horizontal and vertical physical elements of the forest. The physical appearance of canopy and subcanopy trees and snags, shrub and herbaceous layers and downed woody material.
Standard Deviation (SD)	A measure of the variability or spread of the measurements about the mean. It is calculated as the positive square root of the variance.
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.
Stomata	Microscopic pores found on the under side of leaves.
Stomatal Closure	The movement of stomata guard cells to slow or prevent gas exchange between the plant and its environment.
Storativity	The volume of water an aquifer releases from or takes into storage due to pressure change.
Stratify	Layering of lakes into two or more non-mixing layers; in summer, typically a layer of warmer, less dense water lies on a cooler, denser layer; in winter, typically a layer of very cold (<4°C), less dense water overlies warmer, denser water (approximately 4°C).
Stratigraphy (Historical)	The succession and age of strata of rock and unconsolidated material. Also concerns the form, distribution, lithologic composition, fossil content and other properties of the strata.

Stream Flow	The movement of surface water in a stream channel, usually measured in cubic metres per second (m^3/s).
Stream-Day	Maximum daily production rate (design capacity) for equipment. Takes into account non-operational time due to plant turnarounds, and/or emergencies. Calculated based on 93% plant availability.
Study Area	The geographic limits within which an impact to a key indicator resource or social component is likely to be significant.
Subhydric	Soil moisture conditions where water is removed slowly enough to keep the water table at or near the surface for most of the year; organic and gleyed mineral soils are present as well as permanent seepage less than 30 cm below the surface.
Subhygric	Soil moisture conditions where water is removed slowly enough to keep the soil wet for a significant part of the growing season. There is some temporary seepage and possible mottling below 20 cm.
Submesic	Soil moisture conditions where water is removed readily in relation to supply. Water is available for moderately short periods following precipitation.
Subsoil	The stratum of weathered material that underlies the surface soil, including one or more of the following: (i) that portion of the B horizon left after salvage of upland surface soil; (ii) the C horizon of an upland soil; (iii) underlying parent material at an upland location that is rated good, fair or poor; and (iv) mineral material below an organic layer at a location other than upland, that is rated good, fair or poor.
Subxeric	Soil moisture conditions where water is removed rapidly in relation to supply. Soil is moist for short periods following precipitation.
Succession	A series of dynamic changes by which one group of organisms succeeds another through stages leading to a climax community.
Supernatant	The liquidor clear fluid above a precipitate or sediment
Synthetic Crude Oil	A mixture of hydrocarbons, similar to crude oil, derived from upgrading bitumen from oil sands.

Taxa	A group of organisms of any taxonomic rank (e.g., family, genus, or species).
Thallus	A simple vegetative body undifferentiated into true leaves, stem and root, ranging from an aggregation of filaments to a complex plantlike form.
Thalweg	A line extending longitudinally along a watercourse following the deepest portion of the channel.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Threshold Chemicals	Chemicals that act via a threshold mechanism of action require a minimal concentration level to produce adverse effects. Below this specific threshold level, there is no potential for adverse effects to occur.
Threshold Limit Value (TLV)	The air concentration of a chemical below which workers may be repeatedly exposed day after day, without any occurrence of health effects. Threshold limit values are recommended occupational exposure limits designed to control potential adverse effects associated with workplace exposure.
Till	Sediments laid down by glacial ice.
Topsoil	Ae, Ah, Ahe, Ahj and gleyed and weakly gleyed versions of these horizons are usually considered to be part of the topsoil.
Total Dissolved Solids (TDS)	The total concentration of all dissolved compounds solids found in a water sample.
Total Recoverable Hydrocarbons	A term that refers to total petroleum hydrocarbons recovered using a solvent-specific extraction procedure.
Total Reduced Sulphur (TRS)	A term used to collectively describe hydrogen sulphide and mercaptans.
Total Suspended Solids (TSS)	The amount of suspended substances in a water sample.
Toxic	A substance, dose or concentration that is harmful to a living organism.

Toxicity	The inherent potential or capacity of a material to cause adverse effects in a living organism.
Toxicity Reference Value (TRV)	The maximum acceptable dose (per unit body weight and unit of time) of a chemical to which a specified receptor can be exposed. Also referred to as exposure limit.
Traditional 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.
Traditional Plant Potential	A ranking system used to determine and map the relative abundance of traditional use plant species among different vegetation types or land cover classes within the landscape.
Traditional Resources	Plants, animals and mineral resources that are traditionally used by indigenous populations.
Traditional Use Plants	Plants used by aboriginal people of a region as part of their traditional lifestyle for food, ceremonial, medicinal and other purposes.
Training Site	A group of selected satellite imagery pixels used to define the spectral signature of a particular map unit for land classification purposes.
Transmissivity	The product of the average coefficient of hydraulic conductivity (or permeability) and the thickness of the aquifer. Consequently, transmissivity is the rate of flow under a hydraulic gradient equal to unity through a cross-section of unit width over the whole thickness of the aquifer.
Transpiration	The transfer of water from soil and plant surfaces to the air.
Treater	A vessel in which oil is treated for the removal of sediment and water using heat, chemicals and/or electricity.
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.
Understorey	Trees or other vegetation in a forest that exist below the main canopy level.
Ungulate	Belonging to the former order Ungulata, now divided into the orders Perissodactyla and Artiodactyla, and composed of the hoofed mammals such as horses, cattle, deer, swine and elephants.
Upland	Areas that have typical ground slopes of 1 to 3% and are better-drainage.
Upset Conditions	An acute time period within which usual conditions become highly unfavourable; severity and duration may vary.
Vascular Plant	Plants possessing conductive tissues (e.g., veins) for the transport of water and food.
Volatile Organic Compounds (VOC)	Volatile Organic Compounds include aldehydes and all of the hydrocarbons except for ethane and methane. VOCs represent the airborne organic compounds likely to undergo or have a role in the chemical transformation of pollutants in the atmosphere.
Water Sand	A water-saturated sand unit occurring within a geological formation.
Water Table	The shallowest saturated ground below ground level – technically, that surface of a body of unconfined groundwater in which the pressure is equal to atmospheric pressure.
Water Yield	Runoff, including groundwater outflow that appears in the stream, plus groundwater outflow that leaves the basin underground. Water yield is the precipitation minus the evapotranspiration.
Waterbody	A standing body of water such as a lake or pond.
Watercourse	A flowing body of water such as a river, stream or creek.
Watershed	The entire surface drainage area that contributes water to a lake or river.
Weeds	Plants that are defined as controlled weeds, nuisance weeds, or noxious weeds by the Weed Control Act, as amended.
Wellbore	Also borehole. The hole drilled by the bit (can be cased or open).

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.
Wind Shear	A difference in wind speed and/or direction over a relatively short distance in the atmosphere.
Windrose	Graphic pie-type representation of frequencies of wind directions and speeds over a period of time (e.g., one year) for a meteorological station.
Xeric	Soil moisture conditions where water is removed very rapidly in relation to supply. Soil is only moist for a very short time following precipitation.
Young of the Year (YOY)	Fish at age 0, within the first year after hatching.

ABBREVIATIONS

°	Degree
°C	Temperature in degrees Celsius
%	Percent
%OM	Percent Organic Matter
≥	More than or equal to
<	Less than
>	More than
±	Plus or minus
≤	Less than or equal to
2-D	Two dimensional
3-D	Three dimensional
AAAQO	Alberta Ambient Air Quality Objectives
AAC	Annual Allowable Cut
AADT	Annual Average Daily Traffic Counts
AAFRD	Alberta Agriculture, Food And Rural Development
ACGIH	American Conference of Governmental Industrial Hygienists
AEII	Alberta Employment, Immigration and Industry
AENV	Alberta Environment
AEP	Alberta Environmental Protection
AGL	Above Ground Level
AHW	Alberta Health and Wellness
AICc	Akaike’s Information Criterion
Al	Aluminum
Albian Sands	Albian Sands Energy Inc. (Muskeg River Mine)
Al-Pac	Alberta-Pacific Forest Industries Inc.
AMAH	Alberta Municipal Affairs and Housing
ANC	Acid Neutralizing Capacity
ANC_{lim}	Critical value for acid neutralizing capacity
ANC_{org}	Weak Organic Acids
ANHIC	Alberta Natural Heritage Information Centre
ANOVA	Analysis of Variance
ANPC	Alberta Native Plant Council
AOSERP	Alberta Oil Sands Environmental Research Program
AOSP	Athabasca Oil Sands Project
AP	Aquifer Productivity

AQS	Air Quality Monitoring Station
ARC	Alberta Research Council
AREA_CV	Patch Size Coefficient of Variation
AREA_MD	Patch Size Median
AREA_MN	Patch Size Mean
AREA_SD	Patch Size Standard Deviation
ARHA	Aspen Regional Health Authority
ASIR	Age-Standardized Incidence Rates
ASMR	Age-Standardized Mortality Rates
ASRD	Alberta Sustainable Resource Development
ATC	Athabasca Tribal Council
ATC-APCA	Athabasca Tribal Council - All Parties Core Agreement
atm	Atmosphere
ATPRC	Alberta Tourism, Parks, Recreation and Culture
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	All-terrain vehicle
AVI	Alberta Vegetation Inventory
Aw	Aspen (Populus Tremuloides)
AWI	Alberta Wetlands Inventory
B	Bog
BC	Base Cation
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BC/Al	Base Cation/Aluminum
BC/H	Base Cation/Hydrogen
BCF	Bioconcentration Factors
BFW	Boiler Feedwater
Bhp	Brake-horsepower
BLFN	Beaver Lake First Nation
BMC	Benchmark Concentration
$\mathbf{BMD_{05}}$	Benchmark Dose
$\mathbf{BMDL_{05}}$	Benchmark Dose Confidence Limit
BMI	Body Mass Index
bpcd	Barrels per calendar day
bpd	Barrels per day
Bs	Shallow Bog
BS&W	Basic Sediment and Water
BSE	Bovine Spongiform Encephalopathy

BSL	Basic sound level
BSOD	Biological Species Observation Database
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
BU	Burn/Partial Burn
Bw	White Birch (Betula Papyrifera)
bw/d	Body weight per day
C	Coniferous
C&R	Conservation And Reclamation
C,C&R	Closure, Conservation And Reclamation
C_1	Methane
C_2	Ethane
C_3+	Hydrocarbon molecules with more than three carbon atoms
C_7	Heptane
Ca	Calcium
CA	Class Area
Ca^{2+}	Calcium base cation (particle)
$CaCO_3$	Calcium carbonate
CadnaA	Computer Aided Noise Attenuation
CAI_AM	Core Area Index Area Weighted Mean
Cal/Kg·°C	Calories per Kilogram degrees Celcius
Cal/m·sec·°C	Calories per metres seconds degrees Celcius
CAPP	Canadian Association of Petroleum Producers
CARB	California Air Resources Board
CASA	Clean Air Strategic Alliance
CBOD	Carbonaceous Biochemical Oxygen Demand
CC	Clearcut Modifier
CCA	Conklin Community Association
CCIS	Canadian Climate Impact Scenarios
CCME	Canadian Council of Ministers of the Environment
CEA	Cumulative Effects Assessment
CEAA	*Canadian Environmental Assessment Act*
CEC	Cation Exchange Capacity
CEMA	Cumulative Environmental Management Association
CEPA	*Canadian Environmental Protection Act*
CFSA	Child and Family Services Authority
CGCM2	Canadian Global Coupled Model – Version 2
CH_4	Methane

CHA	Cardiovascular Hospital Admissions
CHTD	Canadian Historical Temperature Database
CICS	Canadian Institute for Climate Studies
Cl	Chloride
CL	Clearing
CLI	Canada Land Inventory
CLRP	Christina Lake Regional Project
cm	Centimetre
cm^2	Square centimetre
CNIT	Core Needs Income Threshold
CNS	Central Nervous System
CO	Carbon monoxide
CO_2	Carbon dioxide
CONRAD	Canadian Oil Sands Network for Research and Development
COPC	Chemicals of Potential Concern
COPD	Chronic Obstructive Pulmonary Disease
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPDFN	Chipewyan Prairie Dene First Nation
CST	Central Standard Time
CWS	Canada-Wide Standards
d	Day
D	Deciduous
DAWS	De-Aromatized White Spirit Vapours
dB	Decibel, a measure of sound power
dBA	A-weighted decibels
dBC	C-Weighted decibels
dbh	Diameter at Breast Height
DCA	Detrended Correspondence Analysis
DEM	Digital Elevation Model
Devon	Devon Canada Corporation
df	Degrees of Freedom
DFO	Fisheries and Oceans Canada (Note: formerly Department of Fisheries and Oceans Canada)
dis	Disturbed
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DOE	Department of the Environment
DOW	Dangerous Oilfield Waste

DQRA	Detailed Quantitative Risk Assessment
DST	Drill Stem Test
DW	Drinking Water
E	East
E	Eolian
e.g.	For example
EAC	Existing and Approved Case
EC	Effect Concentration
EC	Electrical Conductivity
Eco-SSLs	Ecological Soil Screening Levels
ECS	Early Childhood Services (Education)
EDI	Estimated daily intake
EHS	Environmental Health and Safety
EIA	Environmental Impact Assessment
EIFAC	European Inland Fisheries Advisory Commission
ELC	Ecological Land Classification
EMS	Emergency Medical Services
EnCana	EnCana Corporation
ENN_CV	Euclidean Nearest Neighbour Median
ENN_MD	Euclidean Nearest Neighbour Coefficient of Variation
ENN_MN	Euclidian Nearest Neighbour Distance
ENN_SD	Euclidean Nearest Neighbour Standard Deviation
EPCM	Engineering, Procurement and Construction Management
EPEA	Alberta *Environmental Protection and Enhancement Act*
ERA	Ecological Risk Assessment
ERCB	Energy Resources Conservation Board
ERP	Emergency Response Plan
ESA	Environmentally Significant Area
ESAR	East Sise of the Athabasca River Caribou Range
ESD	Emergency Shut Down
ESL	Effects Screening Level
ESP	Exchangeable Sodium Percentage
ESR	Environmental Setting Report
ESRI	Environmental Systems Research Institute
EST	Eastern Standard Time
et al.	Group of authors
EUB	Alberta Energy and Utilities Board

F	Fluvial
F	Statistical Test Using F Distribution To Determine If Significant Differences Between 2 Means
Fb	Balsam Fir (Abies Balsamea)
FB	Fractional bias
FCSS	Family and Community Support Services
Fg	Glaciofluvial
FLE	Full Load Equivalent
FMA	Forest Management Agreement
FMES	Fort McKay Environmental Services Ltd.
FMFN	Fort McMurray First Nation
FMFN-IRC	Fort McMurray First Nation – Industrial Relations Corporation
FMU	Forestry Management Unit
FPAC	Forest Products Association of Canada
FPTCCCEA	Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment
FRAC_MN	Mean Patch Fractal Dimension
FWKO	Free Water Knock Out
FWMIS	Fish and Wildlife Management Information System
g	Grams
g/bhp-hr	Grams per brake horsepower-hour
g/d	Grams per day
g/L	Grams per litre
$g/m^2/d$	Grams per square metres per day
g/s	Grams per second
GCM	Global Climate Models
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIC	Groundwater Information Center
GIS	Geographic Information System
Golder	Golder Associates Ltd.
GPS	Global Positioning System
GSA	Geological Study Area
H:V	Ratio of Horizontal Length (H) to Vertical Length (V) for a Specific Slope
H^+	Hydrogen Ions
H_2O	Water
H_2S	Hydrogen sulphide

H_2SO_4	Sulfuric acid
ha	Hectare
HC	Health Canada
HCO_3	Bicarbonate
HEC	Human Equivalent Concentration
HEMP	Human Exposure Monitoring Program
HHRA	Human Health Risk Assessment
HLFN	Heart Lake First Nation
HLS	Hot Lime Softener
HMW	High Molecular Weight
HNO_3	Nitric acid (gas)
HQ	Hazard Quotient
HRSG	Heat Recovery Steam Generator
HS	Habitat Suitability
HS&E	Health, Safety and Environment
HSDB	National Library of Medicine’s Hazardous Substances Data Bank
HSI	Habitat Suitability Index
Husky	Husky Energy
Hwy	Highway
Hz	Hertz
i.e.	That is
ID	Improvement District
ID	Interim Directive
IJI	Interspersion/Juxtaposition
ILCR	Incremental Lifetime Cancer Risk
Imperial Oil	Imperial Oil Resources Ventures Limited
INAC	Indian and Northern Affairs Canada
IPCC	Intergovernmental Panel on Climate Change
IPCS	International Programme on Chemical Safety
IPM	Individual PAH Method
IR	Indian Reserve
IR	Ingestion Rate
IRC	Industry Relations Corporation
IRIS	Integrated Risk Information System
IRP	Integrated Resource Plan
ISC3	Industrial Source Complex Model, Version 3
ISO	International Organization for Standardization

ISQG	Interim Sediment Quality Guidelines
JEMA	Jackpine Expansion Mining Area
K	Carrying Capacity
K	Degrees Kelvin
K	Potassium
keq	Kiloequivalent – equal to 1 kmol of hydrogen ion (H^+)
keq N/ha/yr	Kiloequivalent of nitrogen per hectares per year
keq/ha/yr	Kiloequivalent per hectares per year
kg	Kilogram
kg-ww	Kilogram in wet weight
kHz	Kilohertz
KIRs	Key Indicator Resources
km	Kilometre
km/hr	Kilometre per hour
km^2	Square kilometre
kmol	Kilomole
K_{ow}	Octanol-water partition coefficient
kPa	Kilopascals
kW	Kilowatt
L	Litre
L/d	Litre per day
L/ha/yr	Litre per hectare per year
L/kg	Litres per kilogram
LAI	Leaf Area Index
LC50	Lethal Concentration 50
LCR	Lifetime Cancer Risk
LEC	Lowest Effective Concentration
L_{eq}	Equivalent continuous sound level
LFg/M	Glaciofluvial and Glaciolacustrine Over Moraine
LFH	Litter, Fibric and Humic
LFN	Low Frequency Noise
Lg	Glaciolacustrine
LGP	Low Ground Pressure
LICA	Lakeland Industry and Community Association
LMW	Low Molecular Weight
LOAEL	Lowest Observed Adverse Effect Level
Log	Base 10 logarithm

-log	Negative logarithm
Log K_{ow}	Logarithmic octanol-water partition coefficient
LP	Low Pressure
LRSYA	Long Run Sustained Yield Average
LSA	Local Study Area
LSD	Legal Subdivision
Lt	Tamarack (Larix Laricina)
LZA	Linkage Zone Analysis
m	Metre
M	Moraine
M.D.	Municipal District
m/s	Metres per second
M1	Morainal – Fine Textured
M2	Morainal – Coarse Textured
m^2	Square metres
m^3	Cubic Metre
m^3/cd	Cubic metres per calendar day
m^3/d	Cubic metre per day
m^3/ha	Cubic metres per hectare
m^3/min	Cubic metres per minute
m^3/mol	Cubic metres per mole
m^3/s	Cubic metres per second
m^3/sd	Cubic meters per stream day
m^3/y	Cubic metres per year
M^4/s^3	SI unit for Buoyancy Flux
MA DEP	Massachusetts Department of Environmental Protection
MAC	Maximum Accepatable Concentration
MAI	Mean Annual Increment
masl	Metres above sea level
max.	Maximum
mb	Millibar
mbgs	Meters below ground surface
mbKB	Meters below Kelly Bushing
mbsl	Meters below seal level
mbtc	Meters below top of casing
MCC	Motor Control Centre
MDL	Method detection limit
MEG	MEG Energy Corp.

meq/L	Millequivalent per litre
Mg	Magnesium
mg	Milligrams
mg/kg	Milligrams per kilogram
mg/kg BW/day	Milligrams per kilogram body weight per day
mg/kg/ww	Milligrams per kilogram in wet weight
mg/L	Milligrams per litre
mg/m^2/yr	Milligram per square metre per year
Mg/m^3	Milligrams per cubic metre
Min	Minimum
MJ/m^3	Megajoules per cubic metre
MJ/s	Megajoules per second
mKB	Meters from the Kelly bushing
mm	Millimetre
MM	Mesoscale Model
mm/yr	Millimetre per year
MMBTU/hr	Million British Thermal Units per hour
mmHG	Millimetres of mercury
MN	Mean Patch Size
MNA	Métis Nation of Alberta
mod1	Alberta Vegetation Inventory (AVI) Data Field for Codes Representing Conditions or Treatments Providing Additional Information About the Origin or Condition of the Cover Type
MOU	Memorandum of Understanding
MPOI	Maximum Points of Impingement
MPRL	Maximum Permissible Risk Level
MPS	Mean Patch Size
MRL	Minimum Risk Level
MSC	Meteorological Service of Canada
MSDS	Material Safety Data Sheet
MSI	Municipal Sustainability Initiative
MST	Mountain Standard Time
MW	Megawatt
N	North
N	Fen
N	Nitrogen
n	Number of samples
N/A and n/a	Not applicable

n/d	No data
N_2	Nitrogen Gas
N_2O	Nitrous Oxide
Na	Sodium
NAD	North American Datum
NAIT	Northern Alberta Institute of Technology
NCAR	National Center of Atmospheric Research
NCG	Non-Condensable Gas
ng/g	Nanograms per gram
Ng/m^3	Nanograms per cubic metre
NH_4	Ammonia
NHA	Nunee Health Authority
Ni	Nickel
NLHR	Northern Lights Health Region
NLRHA	Northern Lights Regional Health Authority
NLSD	Northern Lights School Division
NO	Nitric oxide (gas)
NO_2	Nitrogen dioxide (gas)
NO_3^-	Nitrate (particle)
NOAEC	No Observable Adverse Effect Concentration
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NO_X	Oxides of nitrogen (NO, NO_2) (gas), or all nitrogen species (e.g., NO_X, N_2O, NO_3)
NP	Number of Patches
NPV	Net Present Value
Ns	Shallow Fen
NSD	Northland School Division
NSMWG	NO_x/SO_x Management Working Group
NTP	National Toxicity Program Chemical Repository
NTS	National Topographic Survey
NWT	Northwest Territories
O_2	Oxygen (gas)
O_3	Ozone
OEHHA	Office of Environmental; Health Hazard Assessment
OLDCON	Old Coniferous
OMOE	Ontario Ministry of the Environment
ORF	Oil Removal Filter

ORP	Oxidation Reduction Potential
OSCA	*Oil Sands Conservation Act*
OSE	Oil Sands Exploration
OSHA	Alberta Occupational Safety and Health Act
OSVRC	Oil Sands Vegetation Reclamation Committee
OSWWG	Oil Sands Wetlands Working Group
OTSG	Once Through Steam Generator
P	Phosphorous
Pa	Pascal
PACE	Preparation for Academic and Career Education
PAH	Polycyclic Aromatic Hydrocarbon
PAI	Potential Acid Input
PDA	Project Development Area
PDC	Planned Development Case
PDD	Public Disclosure Document
PDF	Probability Density Function
PEL	Probable Effects Level
Pers. Comm.	Personal Communication
PG	Pasquill-Gifford
PHC	Petroleum Hydrocarbon
PID	Pressure Induced Drawdown
Pj	Jack Pine (Pinus Banksiana)
PM	Particulate matter
PM_{10}	Particulate matter with nominally smaller than 10 μm in diameter
$PM_{2.5}$	Particulate matter with nominally smaller than 2.5 μm in diameter
POI	Point of Impingement
ppb	Parts per billion
PPC	Plume Path Coefficient
ppm	Parts per million
ppmv	Parts per million by volume
ppmw	Parts per million by weight
PQRA	Preliminary Quantitative Risk Assessment
PR	Patch Richness
PRMA	Pierre River Mining Area
PSL	Permissible Sound Level
PST	Pacific Standard Time
PSU	Pennsylvania State University

Pt	Platinum
pTDI	provisional Total Daily Intake
PVA	Population Viability Analysis
P-value	The Probability of Quantifying the Strength of the Evidence Against a Null Hypothesis
Q	Quarter (i.e., three months of a year)
QA/QC	Quality Assurance/Quality Control
RAMP	Regional Aquatics Monitoring Program
REL	Reference Exposure Level
RELAD	Regional Lagrangian Acid Deposition Model
RfC	Reference Concentration
RfD	Reference Dose
RFMA	Registered Fur Management Areas
Rge, Rg or R	Range
RHA	Respiratory Hospital Admissions
RIC	Resources Inventory Commitee
RIVAD/ARM3	Regional Impact in Visibility and Acid Deposition/Acid Rain Mountain Mesoscale Model
RIVM	Netherlands National Institute of Public Health and the Environment
RIWG	Regional Issues Working Group
RMWB	Regional Municipality of Wood Buffalo
ROC	Receiver Operating Characteristic
ROW	Rights-of-Way
RQ	Risk Quotients
RSA	Regional Study Area
RsC	Risk-specific concentration
RsD	Risk Specific Dose
RSDS	Regional Sustainable Development Strategy for the Athabasca Oil Sands
RSF	Resource Selection Function
RV	Recreational Vehicle
RWG	Reclamation Working Group
S	South
S	Sulphur
s/cm	Light soaking time in seconds (s) per 1 centimetre
SAC	Strong Acid Cation
SAF	Slurry-at-face
SAGD	Steam Assisted Gravity Drainage
SAGP	Steam Assisted Gravity Push

SA_{org}	Strong Organic Acids
SAR	Sodium Adsorption Ratio
SARA	*Species At Risk Act*
SAS	Statistical Analysis System
Sb	Black Spruce (Picea Mariana)
SCA	Soil Correlation Area
Sd	Standard Deviation
SDI	Simpsons' Diversity Index
SE	Standard Error
SEIA	Socio-Economic Impact Assessment
SETG	Socio-Economic Task Group
SEWG	Sustainable Ecosystems Working Group of CEMA
SF	Slope Factor
SHEI	Shannon's Evenness Index
Shell	Shell Canada Limited
SI	Suitability Index
SK	Saskatchewan
SLERA	Screening-Level Ecological Risk Assessment
SLWRA	Screening-Level Wildlife Risk Assessment
Sm^3	standard cubic metre
SO_2	Sulphur dioxide
SO_4	Sulphate
SO_4^{2-}	Sulphate (particle)
SOPs	Standard Operating Procedures
sp.	Unknown Species (Singular)
spp	Multiple Species
spp.	Unknown Species (Plural)
Sq. Ft.	Square feet
SQG	Soil Quality Guidelines
SRES	Special Report on Emissions Scenarios, by the Intergovernmental Panel on Climate Change
SRU	Sulphur Recovery Unit
ssp.	Subspecies
SSWC	Steady-State Water Chemistry
Statoil	StatoilHydro Canada Ltd.
STEL	Short-term Exposure Limit

Suncor	Suncor Energy Inc. (Lease 86/17, Steepbank, Millennium, Voyageur, Firebag)
Sw	White Spruce (Picea Glauca)
SWWG	Surface Water Working Group of CEMA
Synenco	Synenco Energy Inc.
t/cd	Tonnes per calendar day
t/d	Tonnes per day
t/sd	Tonnes per stream day
TASA	Terrestrial Air Study Area
TC_{05}	Tumourigenic Concentration
TCA	Tolerable Concentration in Air
TCEQ	Texas Commission on Environmental Quality
TCU	True Colour Unit
TD_{05}	Tolerable Dose
TDGR	Transportation of Dangerous Goods Regulations
TDI	Tolerable Daily Intake
TDS	Total Dissolved Solids
TE	Total Edge
TEEM	Terrestrial Environmental Effects Monitoring Program of WBEA
TEF	Toxic Equivalency Factor
TEK	Traditional Ecological Knowledge
Temp.	Temperature
The Project	Christina Lake Regional Project – Phase 3
TK	Traditional Knowledge
TKN	Total Kjeldahl nitrogen
TLU	Traditional Land Use
TLV	Threshold Limit Values
TN	Total Nitrogen
TOC	Total Organic Carbon
TOR	Terms of Reference
TOXLINE	National Library of Medicine's Toxicology Literature Online
TP	Total Phosphorus
TPR	Timber Productivity Rating
TRS	Total Reduced Sulphur
TRV	Toxicity Reference Value
TSS	Total Suspended Solids
TWA	Time Weighted Average
TWINSPAN	Two-Way Indicator Species Analysis

Twp. Or Tp	Township
U.S.	United States
U.S. EPA	United States Environmental Protection Agency
UCLM	Upper Confidence Limits of the Mean
UL	Tolerable Upper Intake Levels
URE	Unit Risk Estimates
USGS	United States Geological Survey
UTF	Underground Test Facility
UTM	Universal Transverse Mercator
V	Vanadium
VEC	Valued Ecosystem Component
VOC	Volatile Organic Compound
VRU	Vapour Recovery Unit
vs.	Versus
W	West
W/m^2	Watts per square metre
W4M	West of the Fourth Meridian
WAC	Weak Acid Cation
WBEA	Wood Buffalo Environmental Association
WBNP	Wood Buffalo National Park
WDS	Water Data System
WF	Windfall
WHO	World Health Organization
WMU	Wildlife Management Unit
WRS	Western Resource Solutions
wt	Weight
wt%	Weight Percentage
yr	Year
z_0	Roughness Length
λ	Rate of increase
µg/d	Micrograms per day
µg/kg	Micrograms per kilogram
µg/kg/d	Micrograms per kilogram per day
µeq/L	Microequivalent per litre
µg/g	Micrograms per gram
µg/kg bw/d	Micrograms per kilogram body weight per day
µg/L	Micrograms per litre

$\mu g/m^3$	Micrograms per cubic metre
$\mu g/m^3/yr$	Micrograms per cubic metre per year
µm	Micron or Micrometre
µPa	Micropascal
µS/cm	Microsiemens per centimetre

APPENDIX 3-I

EXISTING AIR QUALITY AND METEOROLOGY

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APPENDIX 3-II

AIR MODELLING METHODS

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APPENDIX 3-III

AMBIENT AIR QUALITY PREDICTIONS

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

1 AMBIENT PREDICTIONS

1.1 INTRODUCTION

As part of the air quality ambient predictions for the Christina Lake Regional Project – Phase 3 (the Project) Environmental Impact Assessment (EIA), this appendix provides a summary of the Existing and Approved Case (EAC), Project Case and Planned Development Case (PDC) of the estimated ambient air quality of ground-level concentrations.

1.2 EMISSIONS

The emissions used in the EAC, the Project Case and the PDC are presented in the following sections:

- the EAC emissions are located in Section 1.6.2;
- the Project Case emissions are located in Section 1.8.2; and
- the PDC emissions are located in Section 1.9.2.

1.3 REGIONAL SULPHUR DIOXIDE (SO_2) PREDICTIONS

The EAC, Project Case and PDC regional SO_2 concentrations were estimated using the CALPUFF dispersion model. This model is described in further detail in Appendix 3-II.

The maximum predicted 1-hour, 24-hour and annual average ground-level SO_2 concentrations are summarized in Table 1 for the EAC, Project Case and PDC. The modelling results are provided for the Regional Study Area (RSA) and Local Study Area (LSA) with the developed areas included and excluded. The developed areas include the Project plant sites.

Table 1 Regional Existing and Approved Case, Project Case and Planned Development Case Sulphur Dioxide Predictions

Parameter	1-Hour			24-Hour			Annual		
	EAC	Project Case	PDC	EAC	Project Case	PDC	EAC	Project Case	PDC
Local Study Area (LSA)									
peak SO_2 [µg/m^3](a)	941.3	2,049.0	2,045.4	—	—	—	—	—	—
maximum SO_2 [µg/m^3](b)	795.5	1,044.2	1,044.2	185.9	218.0	218.2	7.4	15.6	15.5
maximum SO_2 (excluding developed areas)(b)(c) [µg/m^3]	283.1	416.1	416.3	66.0	118.6	119.8	7.4	15.6	15.5
distance to maximum concentration [km](d)(e)	0.4	0.4	0.4	0.4	0.4	0.4	9.0	0.5	0.5
direction to maximum concentration(d)(e)	SE	SE	SE	SE	SSE	SSE	SSW	E	E
occurrences above AAAQO(e)	0	0	0	0	0	0	0	0	0
areal extent above AAAQO (excluding developed areas)(c)(e) [ha]	0	0	0	0	0	0	0	0	0
Regional Study Area (RSA)									
peak SO_2 [µg/m^3](a)	941.3	2,049.0	2,045.4	—	—	—	—	—	—
maximum SO_2 [µg/m^3](b)	795.5	1,044.2	1,044.2	185.9	218.0	218.2	7.4	15.6	15.5
maximum SO_2 (excluding developed areas)(b)(c) [µg/m^3]	283.1	416.1	416.3	66.0	118.6	119.8	7.4	15.6	15.5
distance to maximum concentration [km](d)(e)	0.4	0.4	0.4	0.4	0.4	0.4	9.0	0.5	0.5
direction to maximum concentration(d)(e)	SE	SE	SE	SE	SSE	SSE	SSW	E	E
occurrences above AAAQO(e)	0	0	0	0	0	0	0	0	0
areal extent above AAAQO (excluding developed areas)(d)(e) [ha]	0	0	0	0	0	0	0	0	0
AAAQO(g) for SO_2 [µg/m^3]	**450**			**150**			**30**		

(a) The peak predictions include the eight highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003) when determining compliance with the AAAQOs.

(b) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(c) Developed areas include the Project plant sites.

(d) Locations are relative to the Central Plant Site.

(e) Locations, number of occurrences and areas are based on the maximum predictions outside developed areas.

— = No value determined.

Note: AAAQO = Alberta Ambient Air Quality Objective.

The following summarizes the EAC, Project Case and PDC SO_2 modelling results excluding the developed areas:

- **Existing and Approved Case**: The maximum 1-hour, 24-hour and annual SO_2 concentrations are shown in Figures 1, 2 and 3, respectively. The maximum 1-hour, 24-hour and annual concentrations in both the RSA and LSA are below the Alberta Ambient Air Quality Objectives (AAAQOs) of 450, 150 and 30 $\mu g/m^3$, respectively.
- **Project Case**: The maximum 1-hour, 24-hour and annual SO_2 concentrations are shown in Figures 4, 5 and 6, respectively. The maximum 1-hour, 24-hour and annual concentrations excluding developed areas in both the RSA and LSA are below the AAAQOs of 450, 150 and 30 $\mu g/m^3$, respectively.
- **Planned Development Case**: The maximum 1-hour, 24-hour and annual SO_2 concentrations are shown in Figures 7, 8 and 9, respectively. The maximum 1-hour, 24-hour and annual concentrations excluding developed areas in both the RSA and LSA are below the AAAQOs of 450, 150 and 30 $\mu g/m^3$, respectively.

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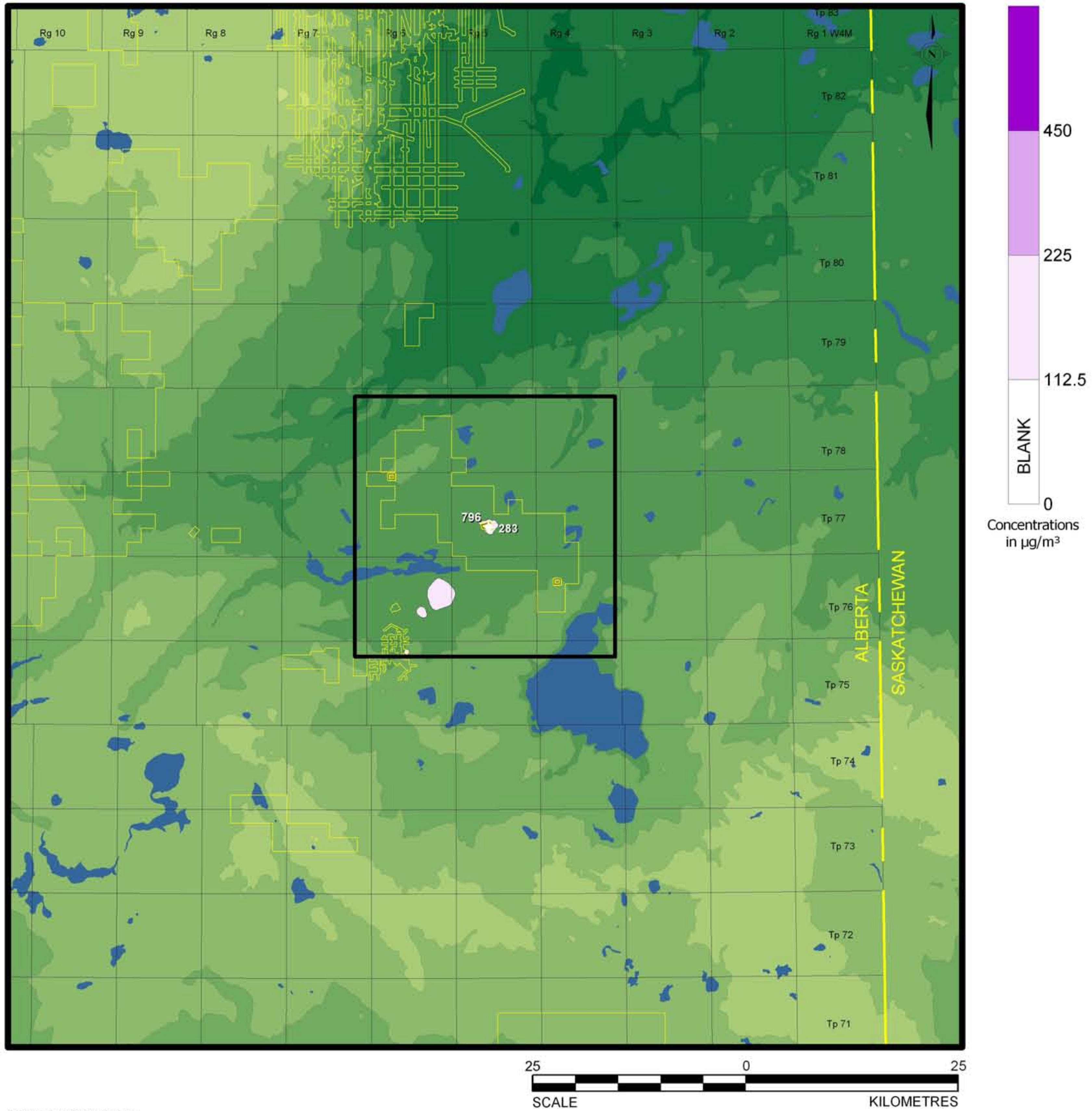
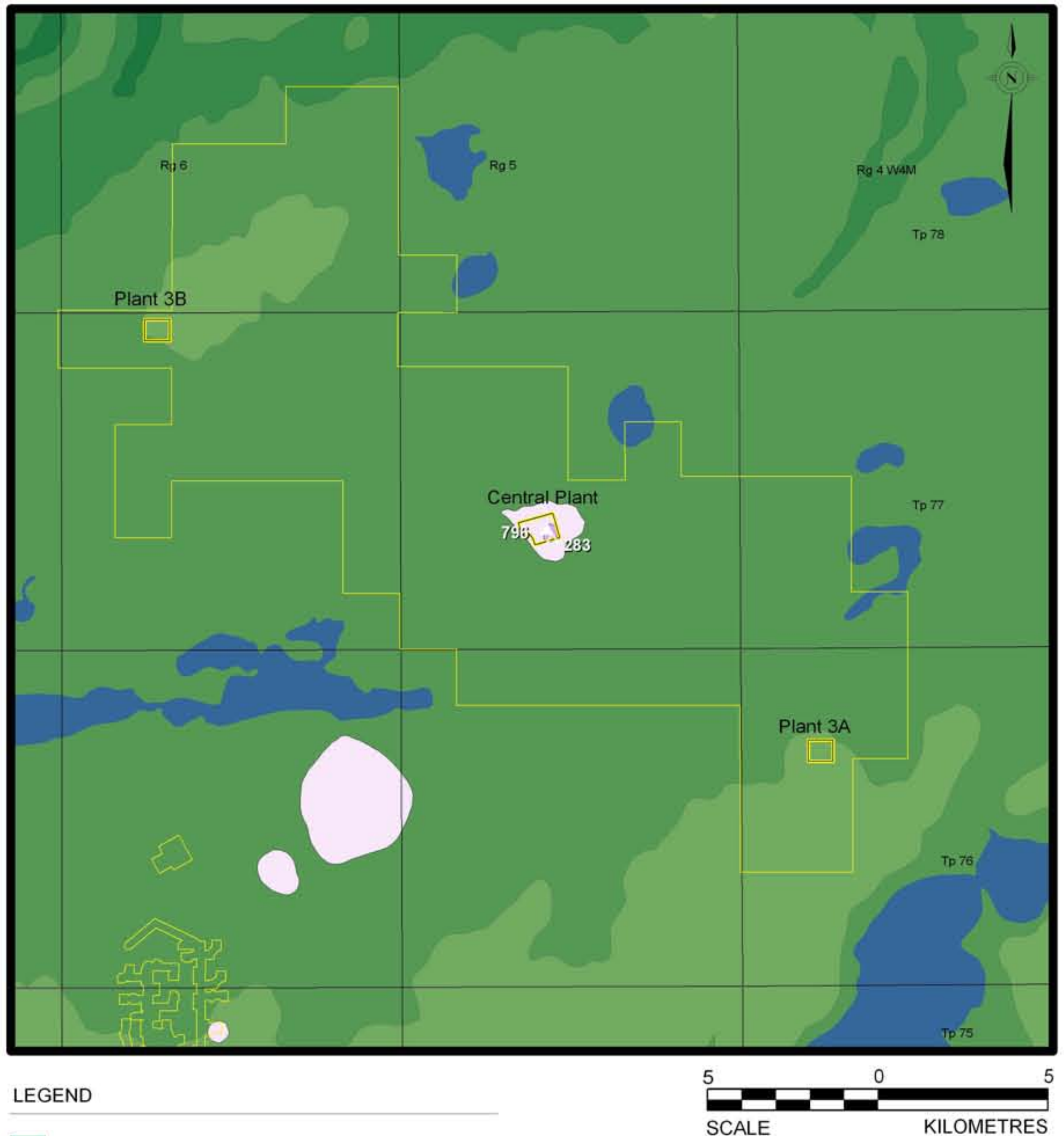
AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- 🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- 🟩 *MEG PLANTSITES*
- ☐ *LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*
- ◆ *MAXIMUM PREDICTION WITHIN RSA.*
- ◇ *MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.*
- ▲ *MAXIMUM PREDICTION WITHIN LSA.*
- △ *MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.*

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
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DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE MAXIMUM 1-HOUR SO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	14/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 1

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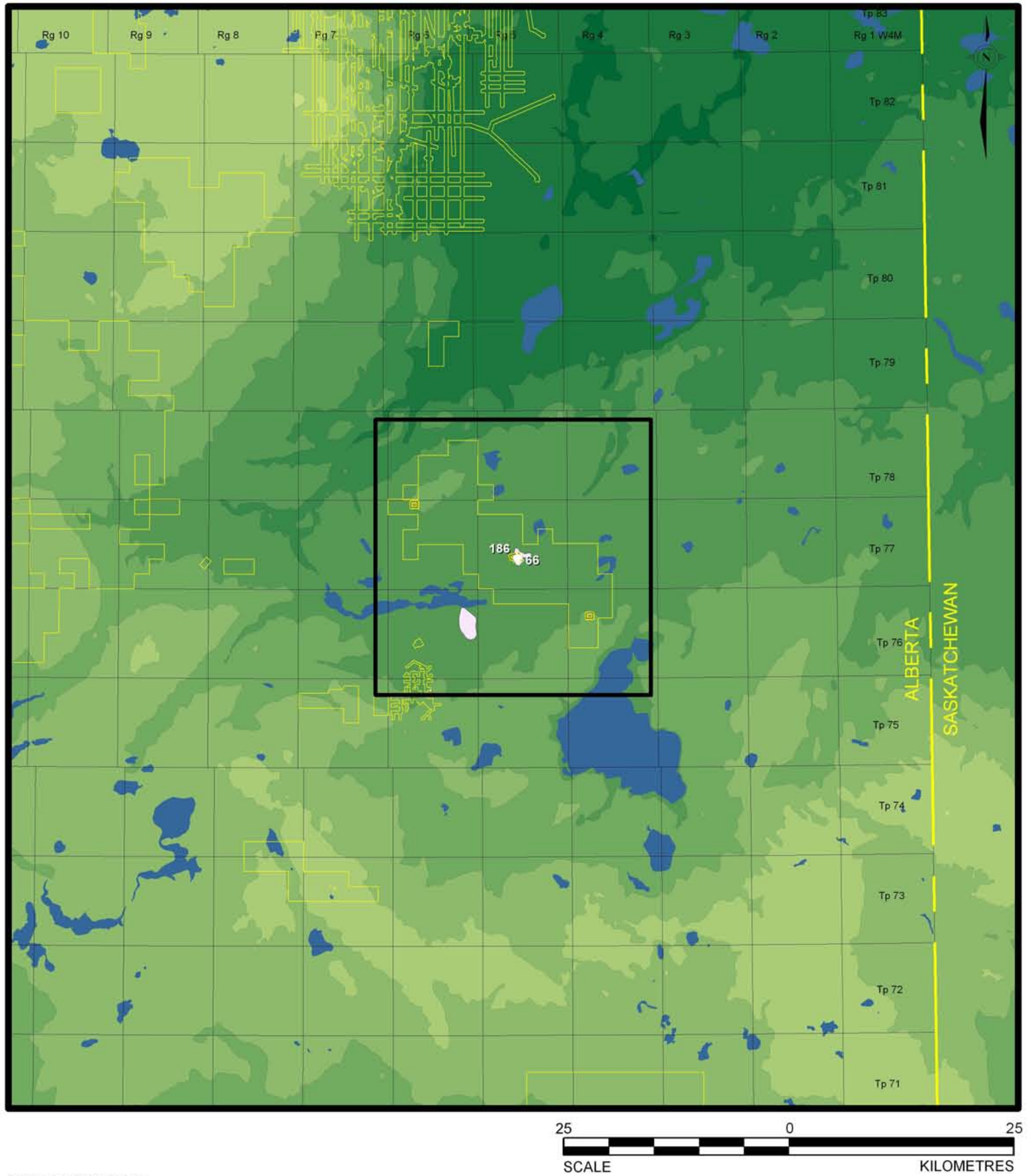
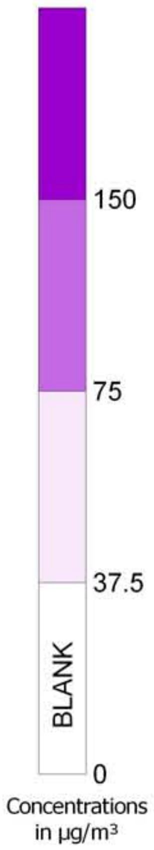
AIR REGIONAL STUDY AREA





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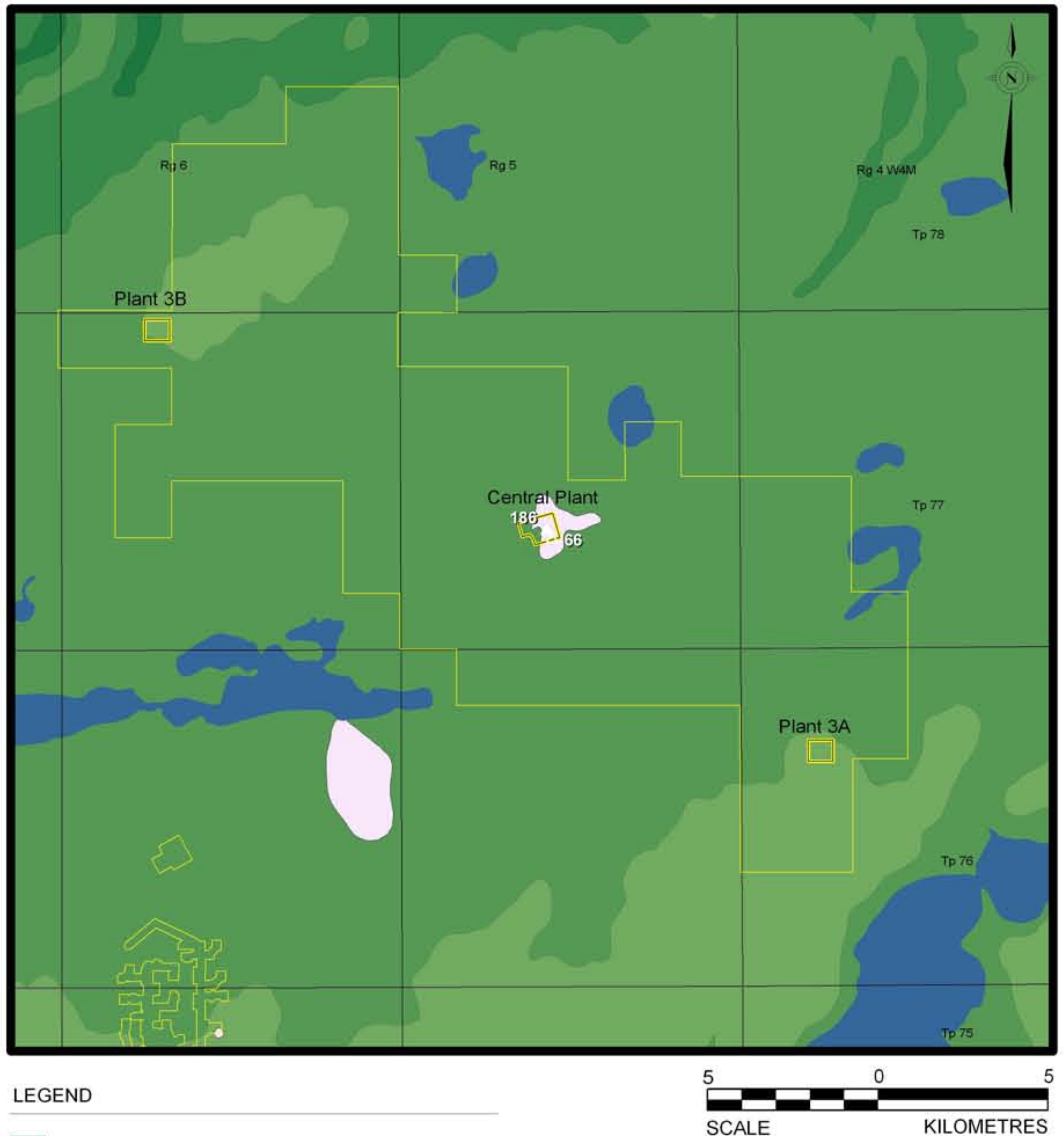

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SCALE: AS SHOWN

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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE
MAXIMUM 24-HOUR SO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	14/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 2

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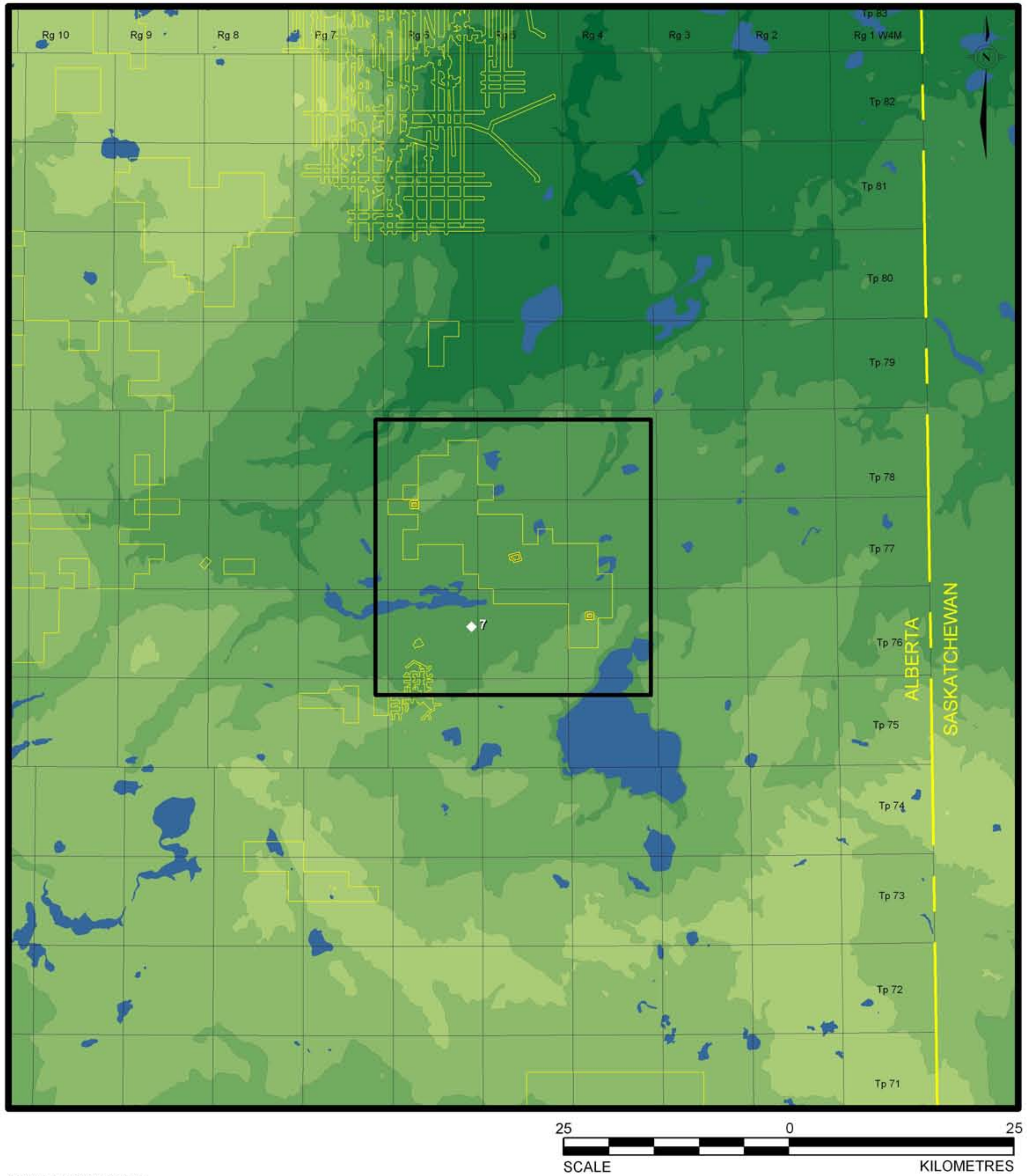

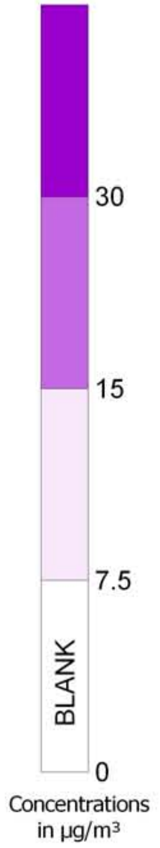

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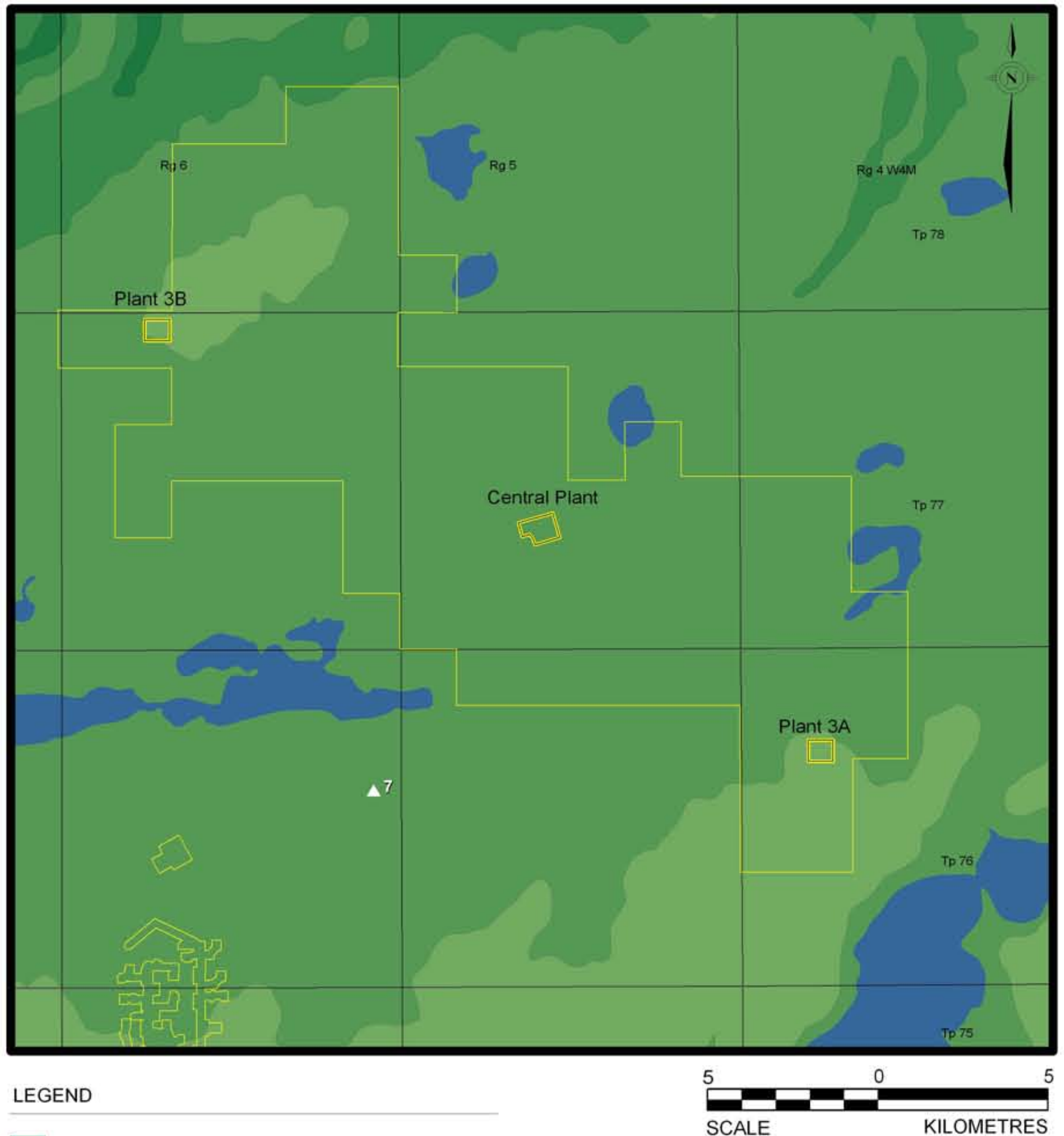

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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE ANNUAL AVERAGE SO_2 PREDICTIONS

MEG ENERGY CORP.

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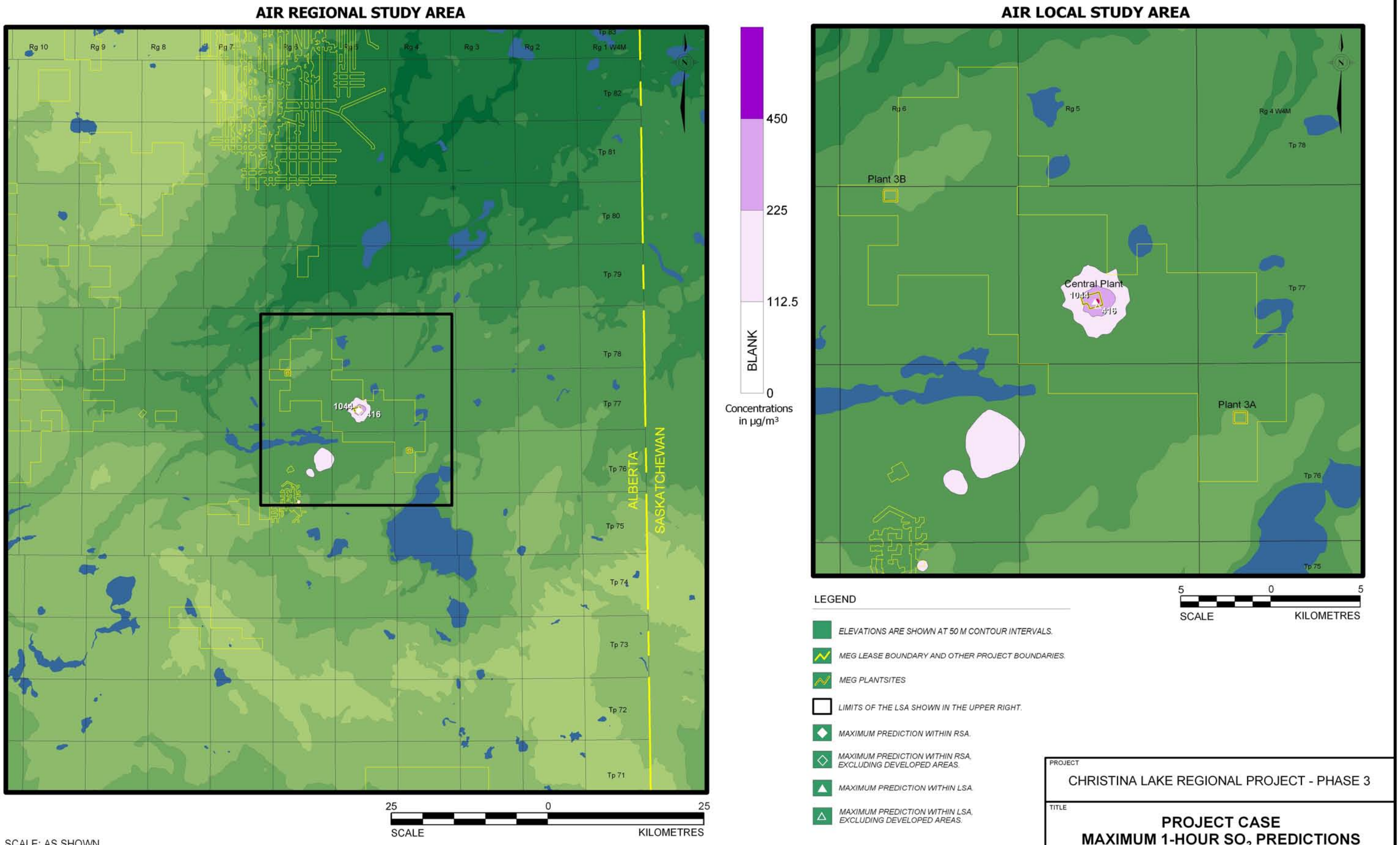
FIGURE: 3



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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE
MAXIMUM 1-HOUR SO_2 PREDICTIONS

MEG ENERGY CORP.

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FIGURE: 4

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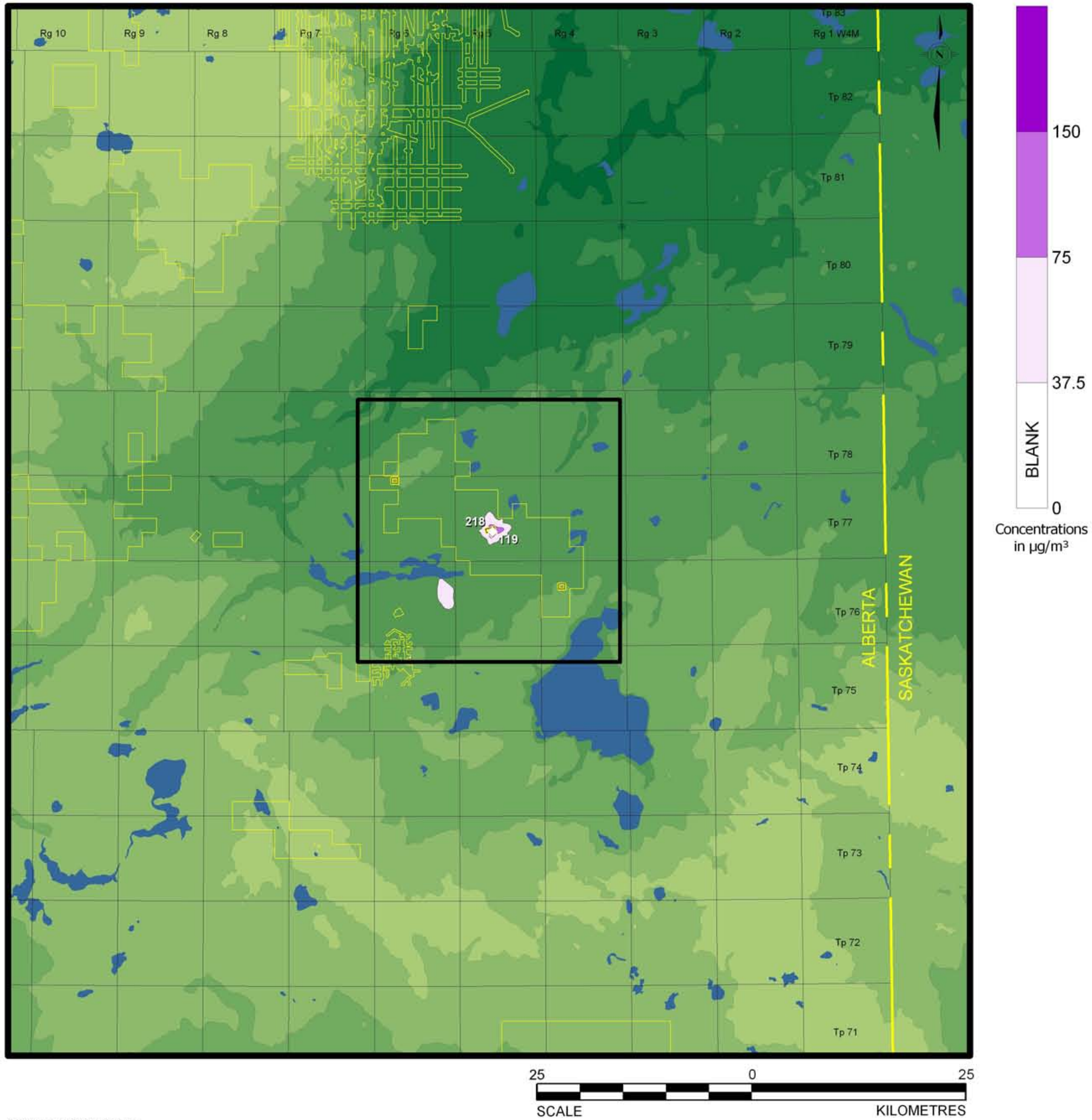
AIR REGIONAL STUDY AREA



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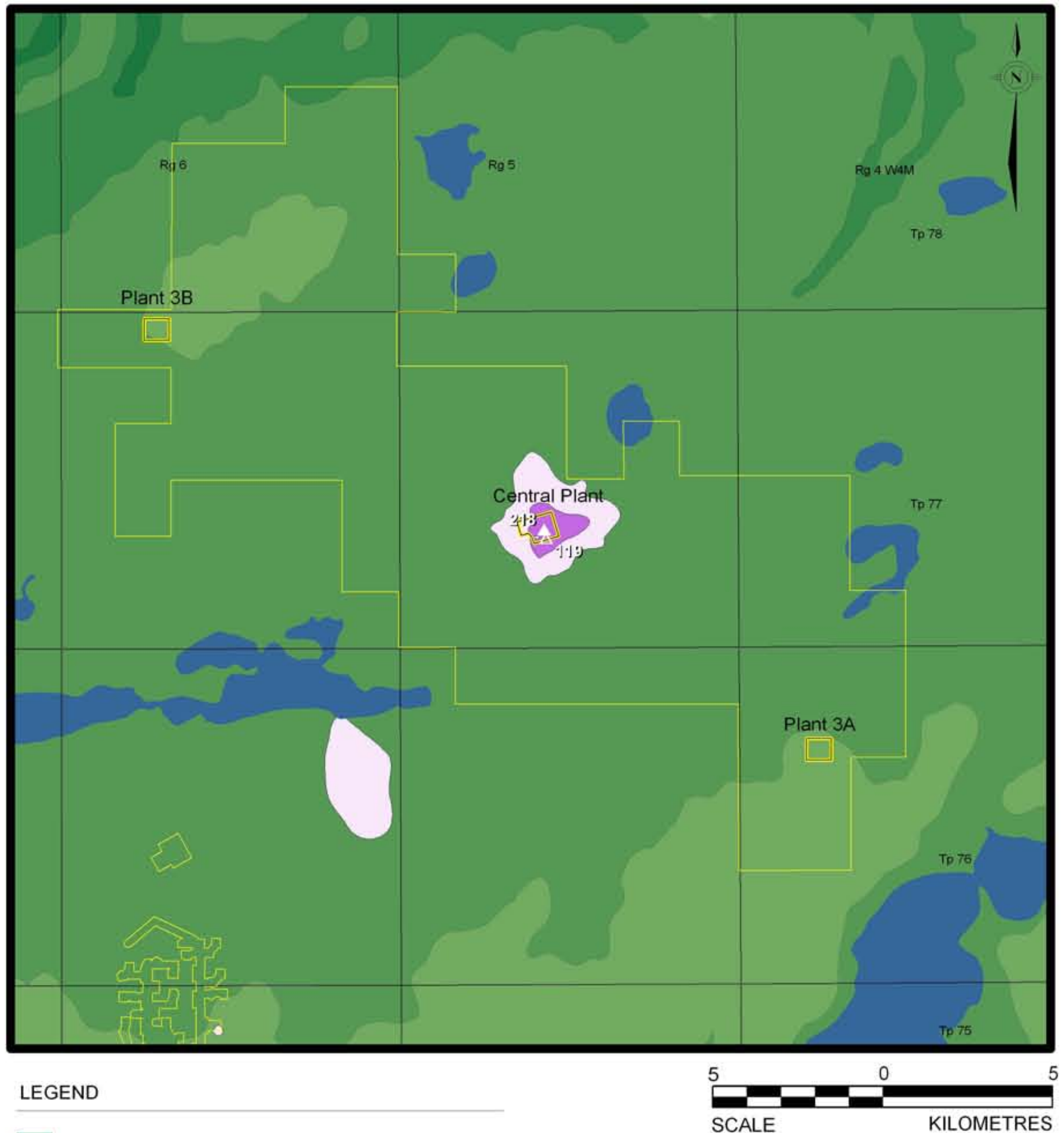

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SCALE: AS SHOWN

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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE
MAXIMUM 24-HOUR SO_2 PREDICTIONS

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REVIEW	IGG	09/04/08

FIGURE: 5

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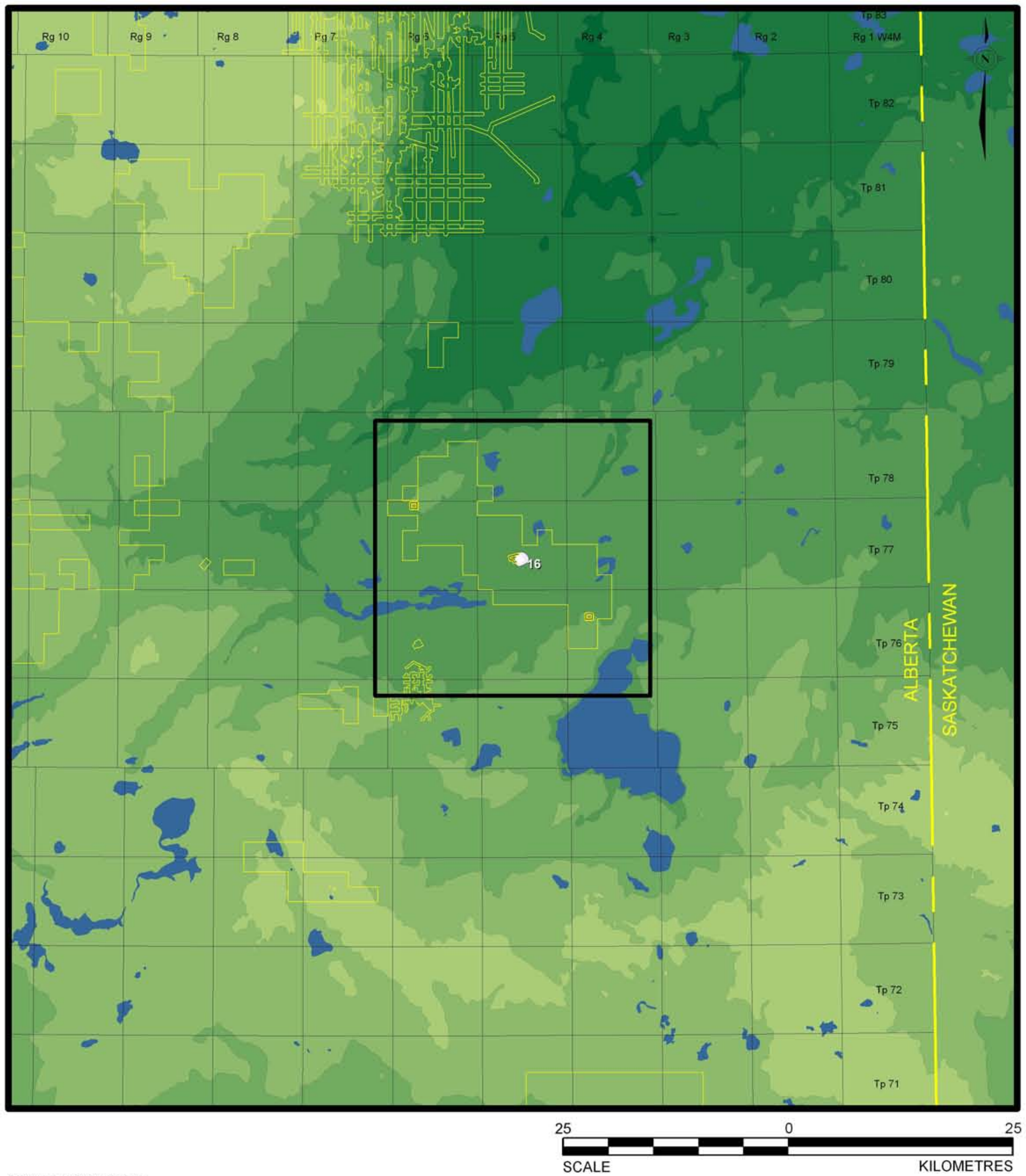

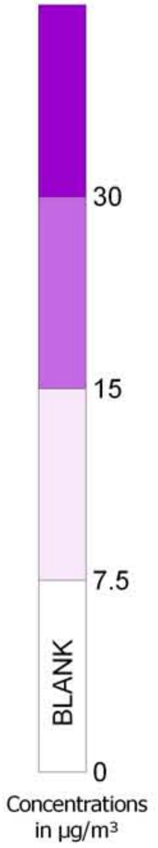

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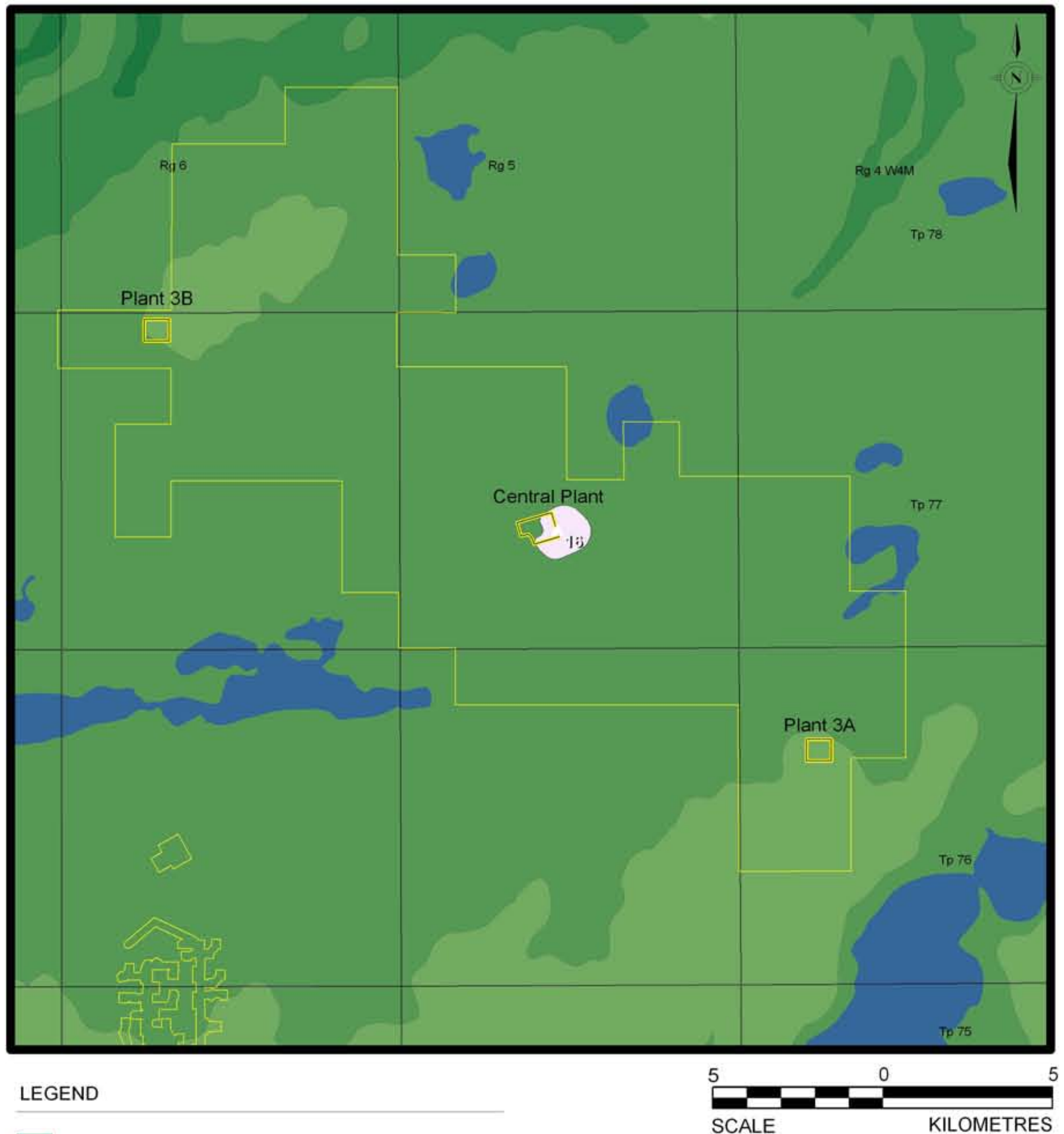

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DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE
ANNUAL AVERAGE SO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	15/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 6

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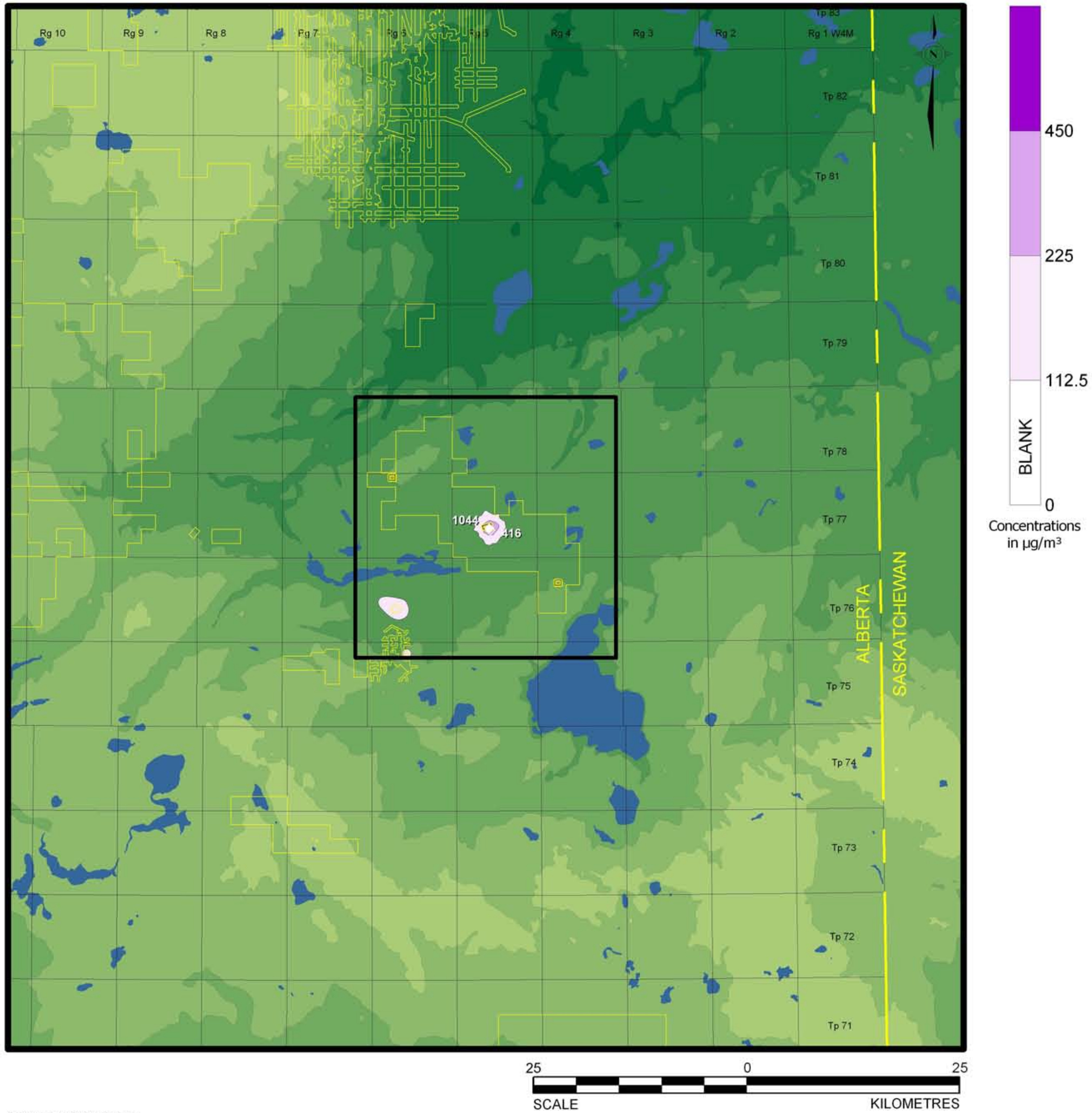
AIR REGIONAL STUDY AREA



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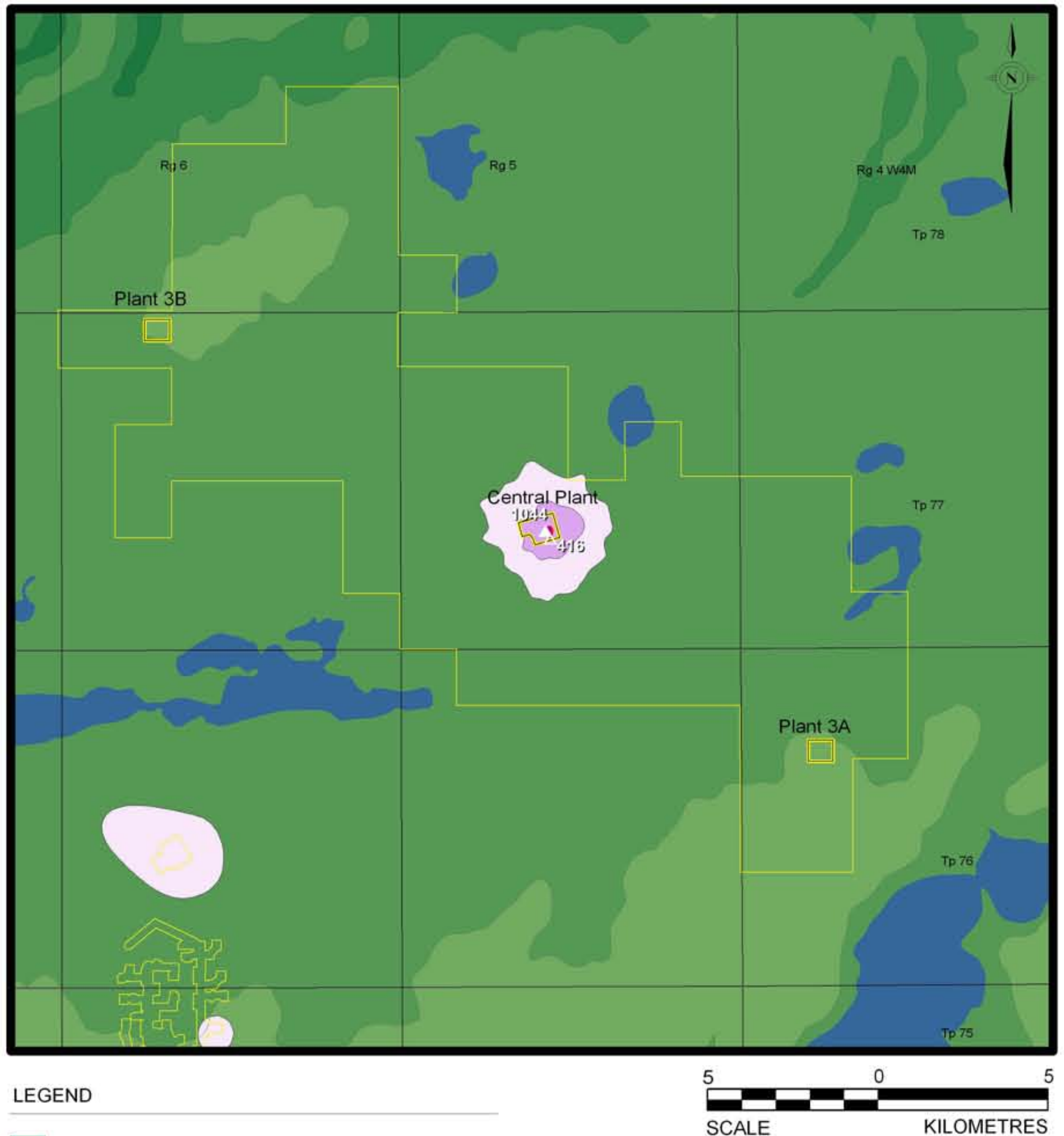

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SCALE: AS SHOWN

REFERENCE

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USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PLANNED DEVELOPMENT CASE
MAXIMUM 1-HOUR SO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	15/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 7

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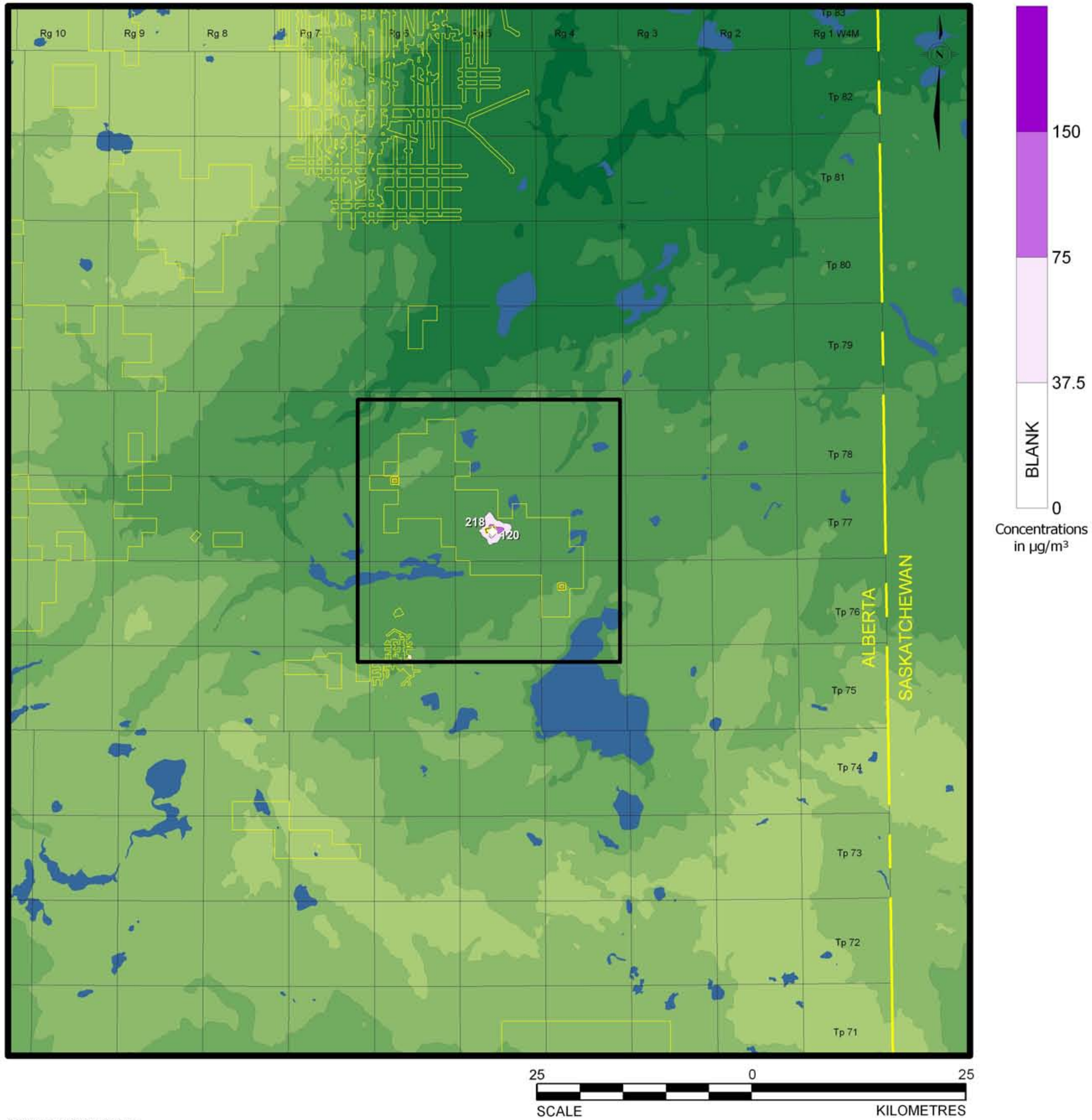
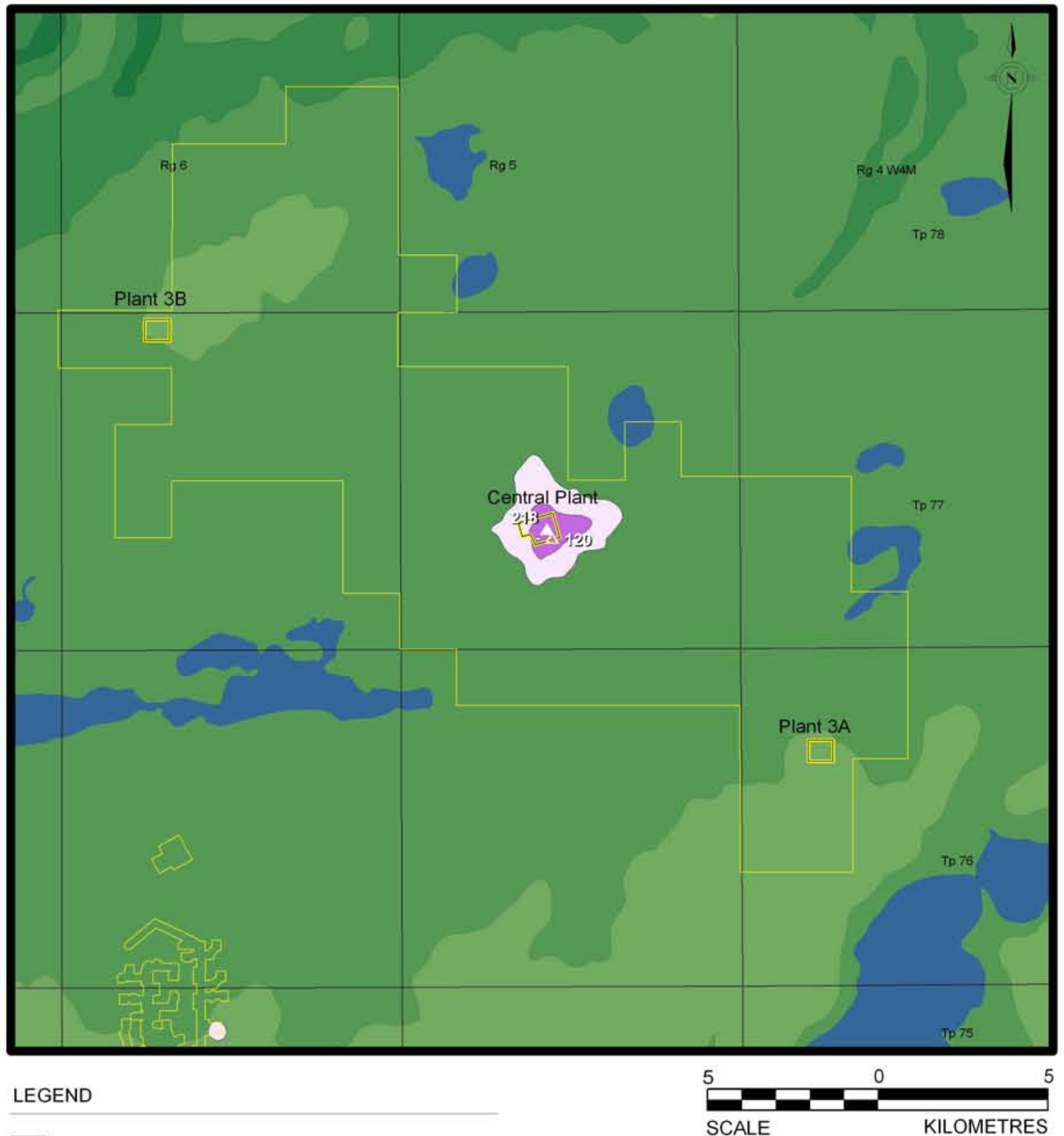
AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- *MEG PLANTSITES*
- ☐ *LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*
- ◆ *MAXIMUM PREDICTION WITHIN RSA.*
- ◇ *MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.*
- ▲ *MAXIMUM PREDICTION WITHIN LSA.*
- △ *MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.*

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PLANNED DEVELOPMENT CASE
MAXIMUM 24-HOUR SO_2 PREDICTIONS

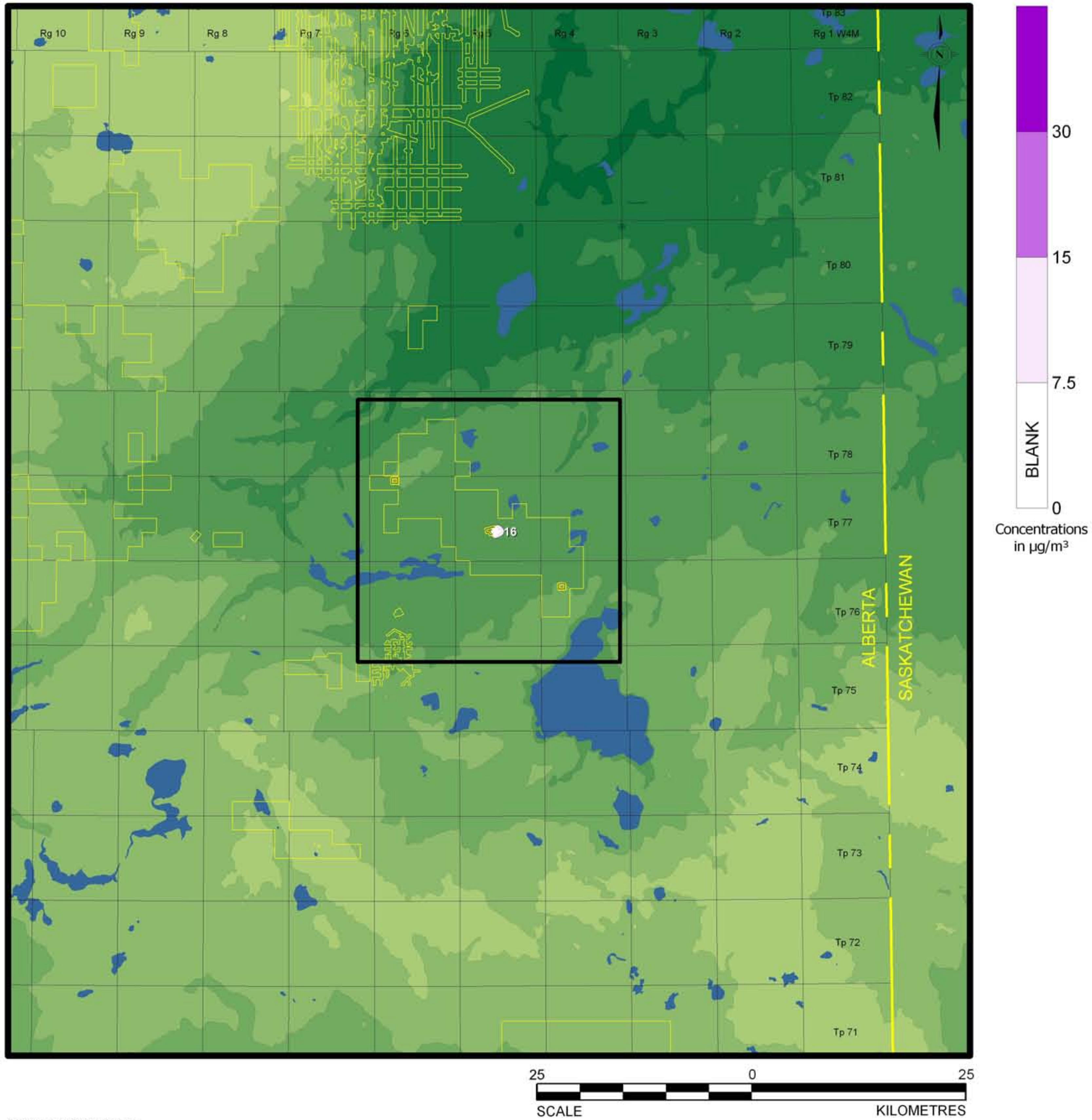
MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	DK	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

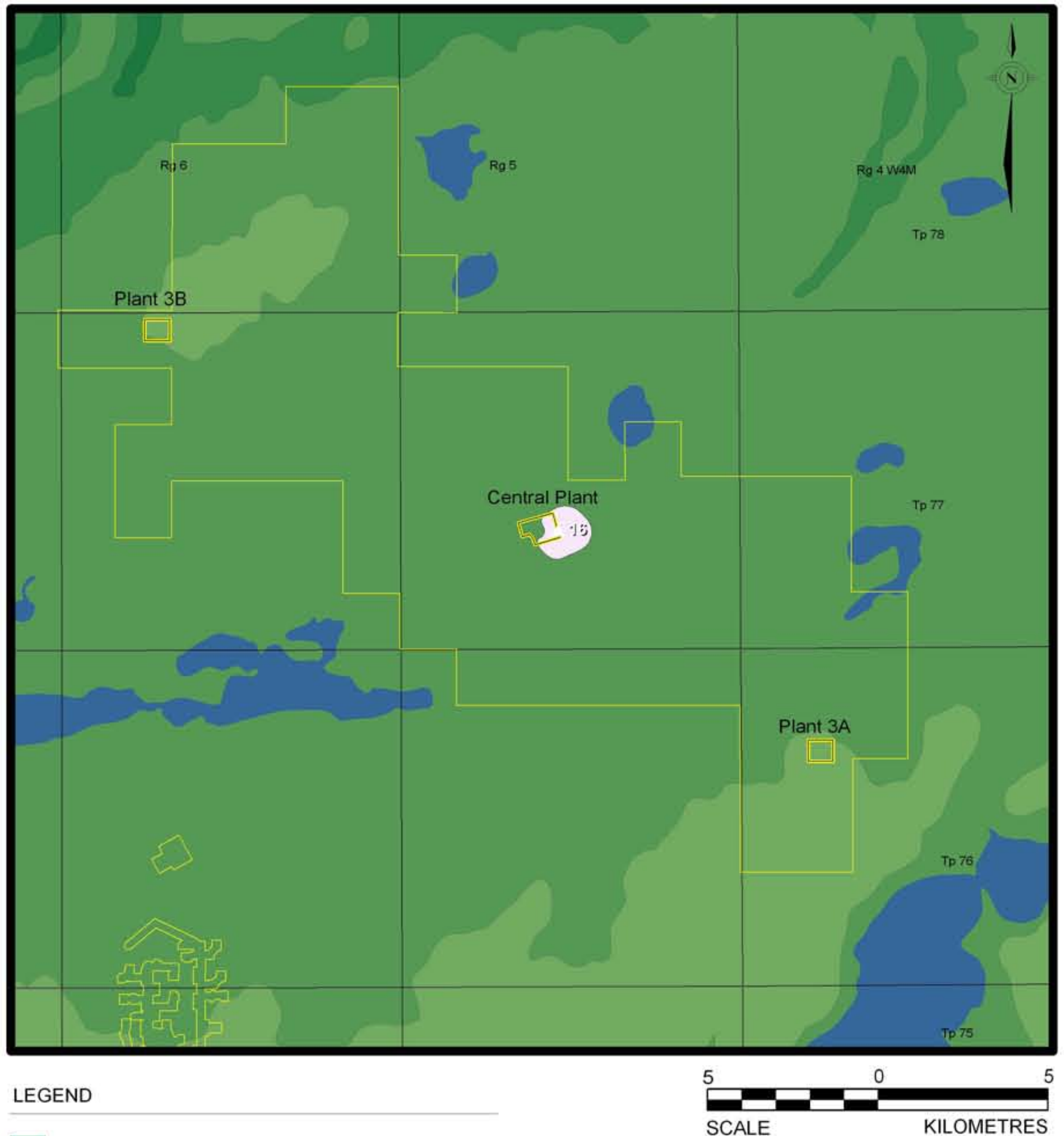
FIGURE: 8

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/PDC_SO2_a.srf

AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- *MEG PLANTSITES*
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- ◇ *MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.*
- ▲ *MAXIMUM PREDICTION WITHIN LSA.*
- △ *MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.*

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PLANNED DEVELOPMENT CASE
ANNUAL AVERAGE SO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	DK	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 9

1.4 REGIONAL NITROGEN DIOXIDE (NO_2) PREDICTIONS

The maximum predicted 1-hour, 24-hour and annual ground-level NO_2 concentrations are presented in Table 2 for the EAC, Project Case and PDC. The modelling results are provided for the RSA and LSA with the developed areas included and excluded. The developed areas include the Project plant sites. There are no ambient air quality objectives for NO_X; however, the ground-level NO_X concentrations are also presented in Table 2 for comparison purposes since predicted NO_2 concentrations are based on NO_X modelling results.

The following summarizes the EAC, Project Case and PDC NO_2 modelling results excluding the developed areas:

- **Existing and Approved Case**: The maximum 1-hour, 24-hour and annual NO_2 concentrations are shown in Figures 10, 11 and 12, respectively. The maximum 1-hour, 24-hour and annual concentrations in both the RSA and LSA are below the AAAQOs of 400, 200 and 60 µg/m³, respectively.
- **Project Case**: The maximum 1-hour, 24-hour and annual NO_2 concentrations are shown in Figures 13, 14 and 15, respectively. The maximum 1-hour, 24-hour and annual concentrations in both the RSA and LSA are below the AAAQOs of 400, 200 and 60 µg/m³, respectively.
- **Planned Development Case**: The maximum 1-hour, 24-hour and annual NO_2 concentrations are shown in Figures 16, 17 and 18, respectively. The maximum 1-hour, 24-hour and annual concentrations in both the RSA and LSA are below the AAAQOs of 400, 200 and 60 µg/m³, respectively.

Table 2 Regional Existing and Approved Case, Project Case and Planned Development Case Oxides of Nitrogen and Nitrogen Dioxide Predictions

Parameter	1-Hour			24-Hour			Annual		
	EAC	Project Case	PDC	EAC	Project Case	PDC	EAC	Project Case	PDC
Local Study Area									
peak NO_X [µg/m^3](a)	743.5	1,329.4	1,330.2	—	—	—	—	—	—
peak NO_2 [µg/m^3](a)	358.6	685.3	686.0	—	—	—	—	—	—
maximum NO_2 [µg/m^3](b)	87.9	173.9	174.8	43.7	46.4	50.2	3.8	6.1	7.1
maximum NO_2 (excluding developed areas)(b)(c) [µg/m^3]	87.9	161.4	161.4	41.8	46.4	50.2	3.8	6.1	7.1
distance to maximum concentration [km](d)(e)	0.4	10.0	10.0	0.4	11.5	11.5	11.5	11.5	11.5
direction to maximum concentration(d)(e)	NNW	SE	SE	NW	WNW	WNW	NW	WNW	WNW
occurrences above AAAQO(e)	0	0	0	0	0	0	0	0	0
areal extent above AAAQO (excluding developed areas)(c)(e) [ha]	0	0	0	0	0	0	0	0	0
Regional Study Area									
peak NO_X [µg/m^3](a)	1,902.6	1,902.6	1,902.8	—	—	—	—	—	—
peak NO_2 [µg/m^3](a)	358.6	685.3	686.0	—	—	—	—	—	—
maximum NO_2 [µg/m^3](b)	158.1	173.9	174.8	65.6	65.7	67.8	5.5	6.1	7.1
maximum NO_2 (excluding developed areas)(b)(c) [µg/m^3]	158.1	161.4	161.4	65.6	65.7	67.8	5.5	6.1	7.1
distance to maximum concentration [km](d)(e)	51.9	10.0	10.0	51.9	51.9	51.9	48.0	11.5	11.5
direction to maximum concentration(d)(e)	NNW	SE	SE	NNW	NNW	NNW	NNW	WNW	WNW
occurrences above AAAQO(e)	0	0	0	0	0	0	0	0	0
areal extent above AAAQO (excluding developed areas)(c)(e) [ha]	0	0	0	0	0	0	0	0	0
AAAQO for NO_2 [µg/m^3]	**400**			**200**			**60**		

(a) The peak predictions include the eight highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003) when determining compliance with the AAAQOs.

(b) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003). The eight highest 1-hour predictions were not excluded from the maximum 24-hour and annual concentrations.

(c) Developed areas include the Project plant sites.

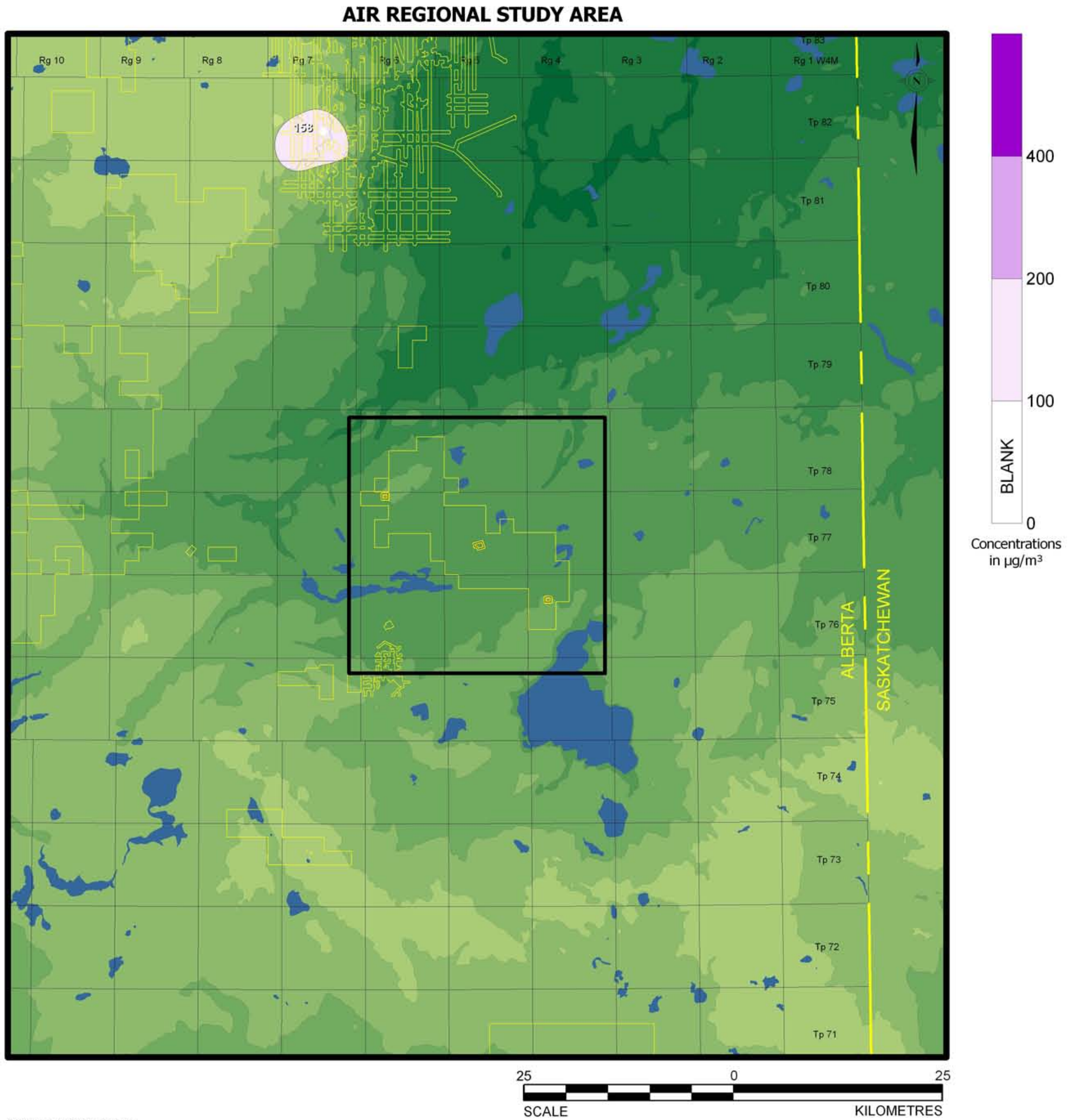
(d) Locations are relative to the Central Plant Site.

(e) Locations, number of occurrences and areas are based on the maximum predictions outside developed areas.

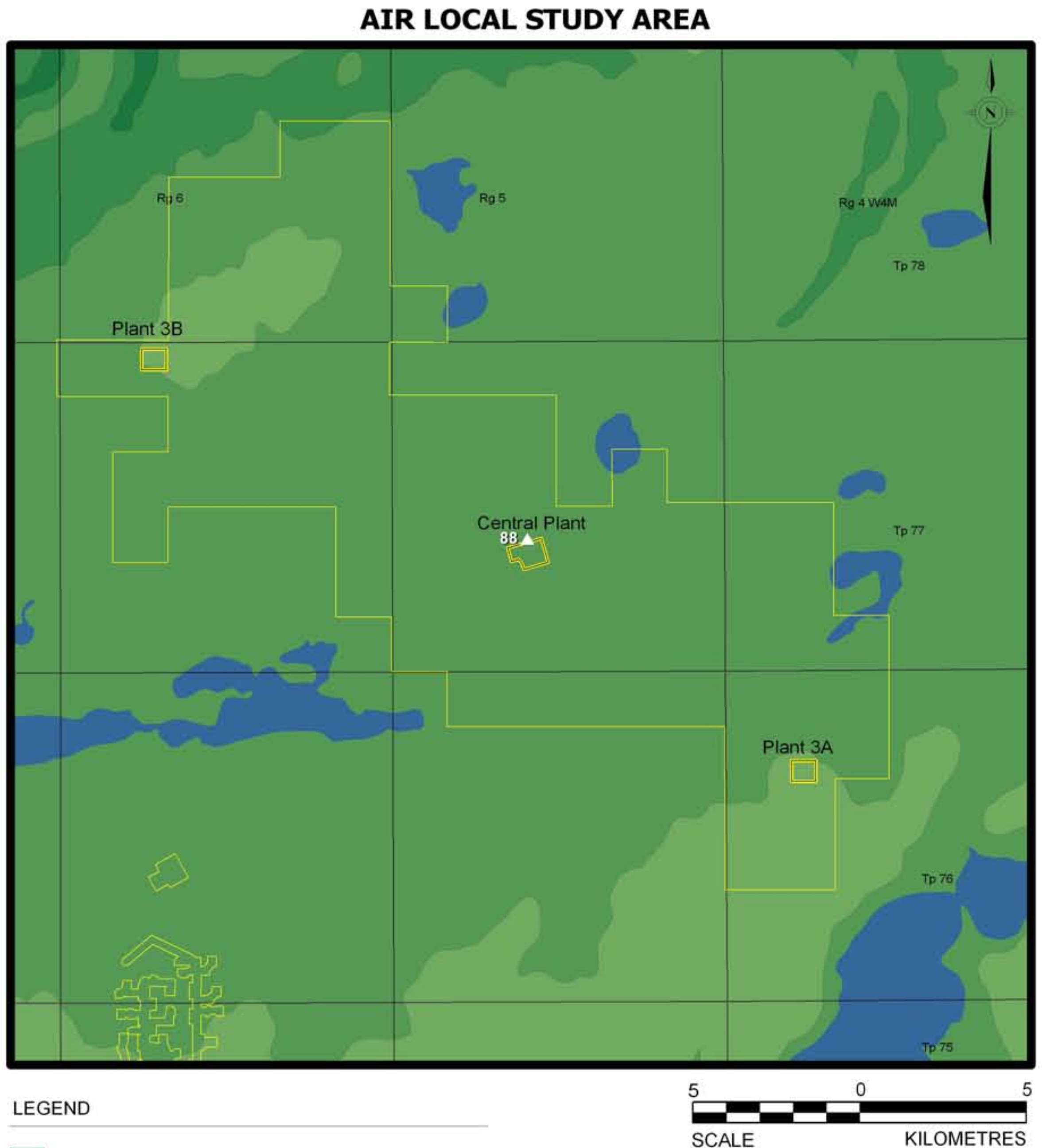
— = No value determined.
Note: AAAQO = Alberta Ambient Air Quality Objective.

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/BAS_NO2_9th_hr.srf

AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- 🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- 🟩 *MEG PLANTSITES*
- ☐ *LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*
- ◆ *MAXIMUM PREDICTION WITHIN RSA.*
- ◇ *MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.*
- ▲ *MAXIMUM PREDICTION WITHIN LSA.*
- △ *MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.*

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE
MAXIMUM 1-HOUR NO_2 PREDICTIONS

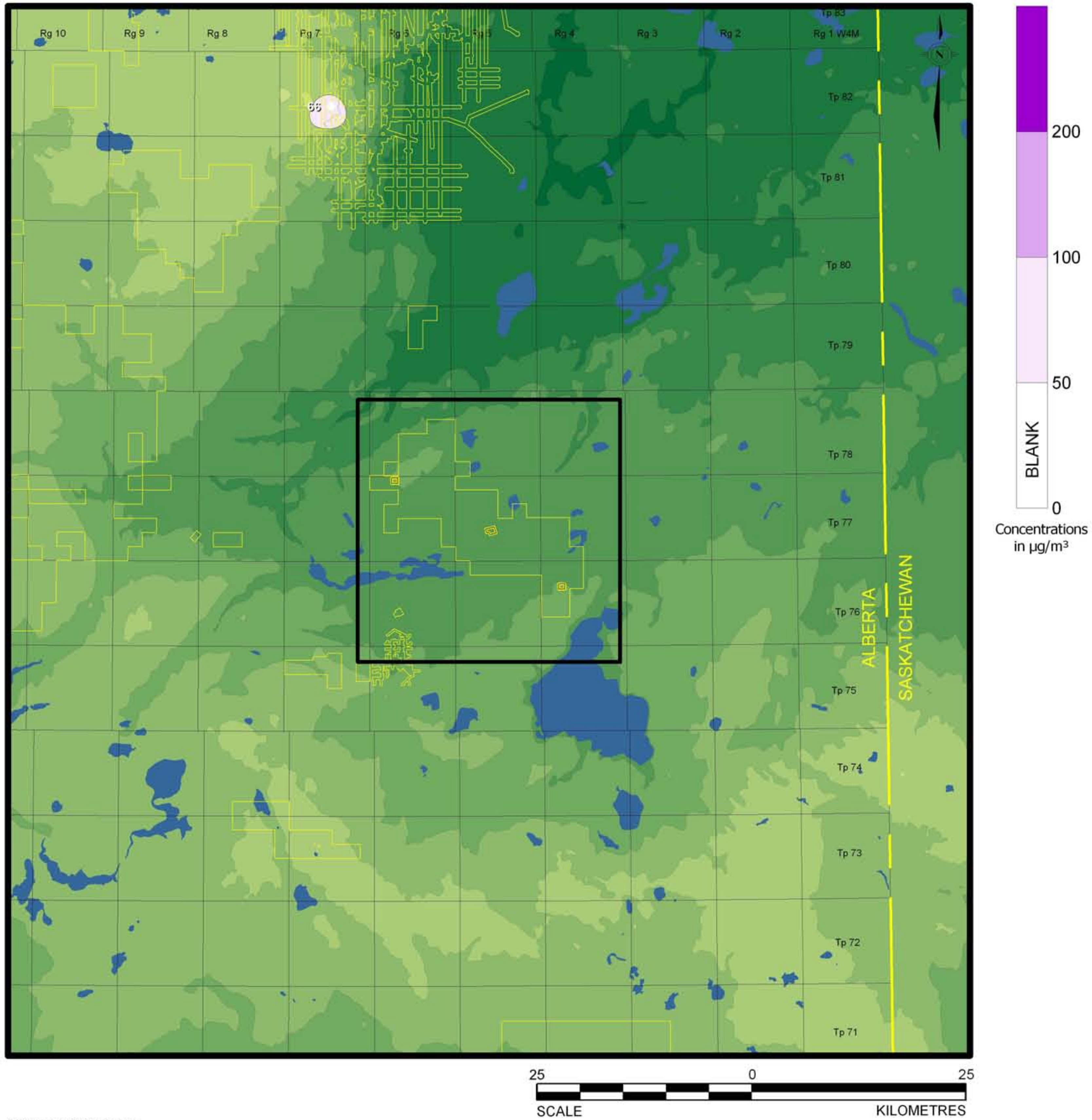
MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	DK	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

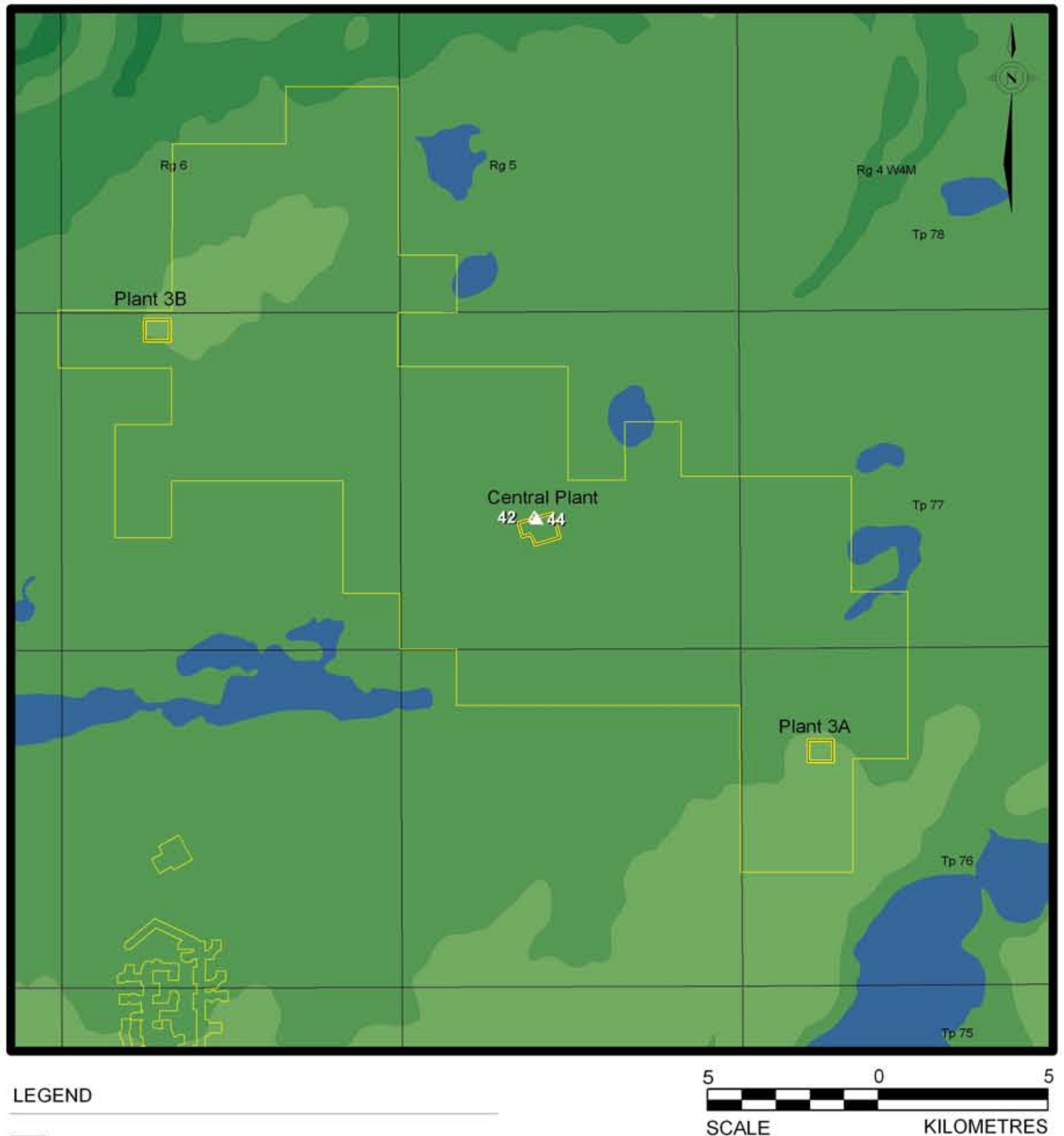
FIGURE: 10

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/BAS_NO2_d.srf

AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- 🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- 🟩 *MEG PLANTSITES*
- ☐ *LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*
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SCALE: AS SHOWN

REFERENCE

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USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE
MAXIMUM 24-HOUR NO_2 PREDICTIONS

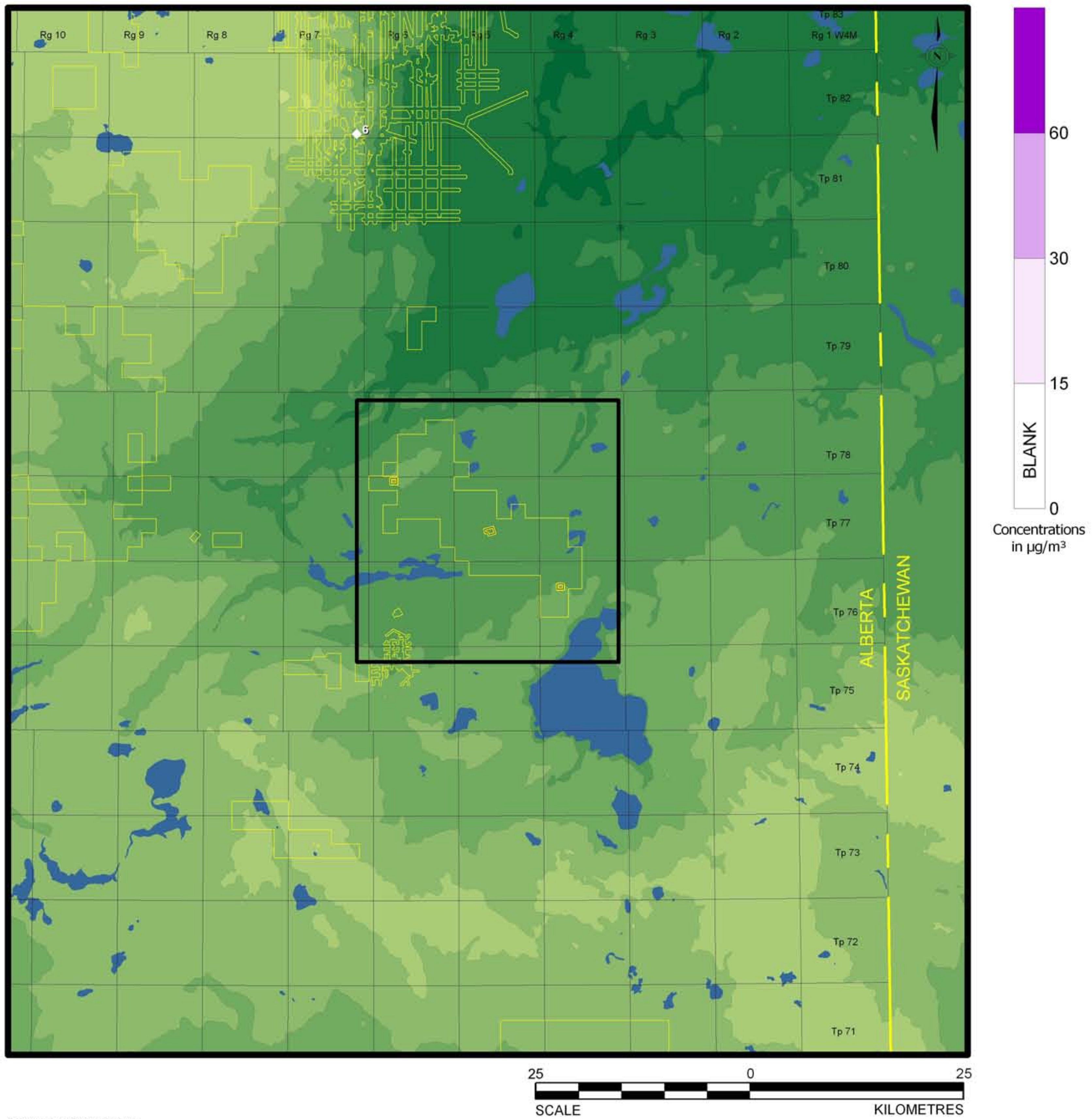
MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	DK	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

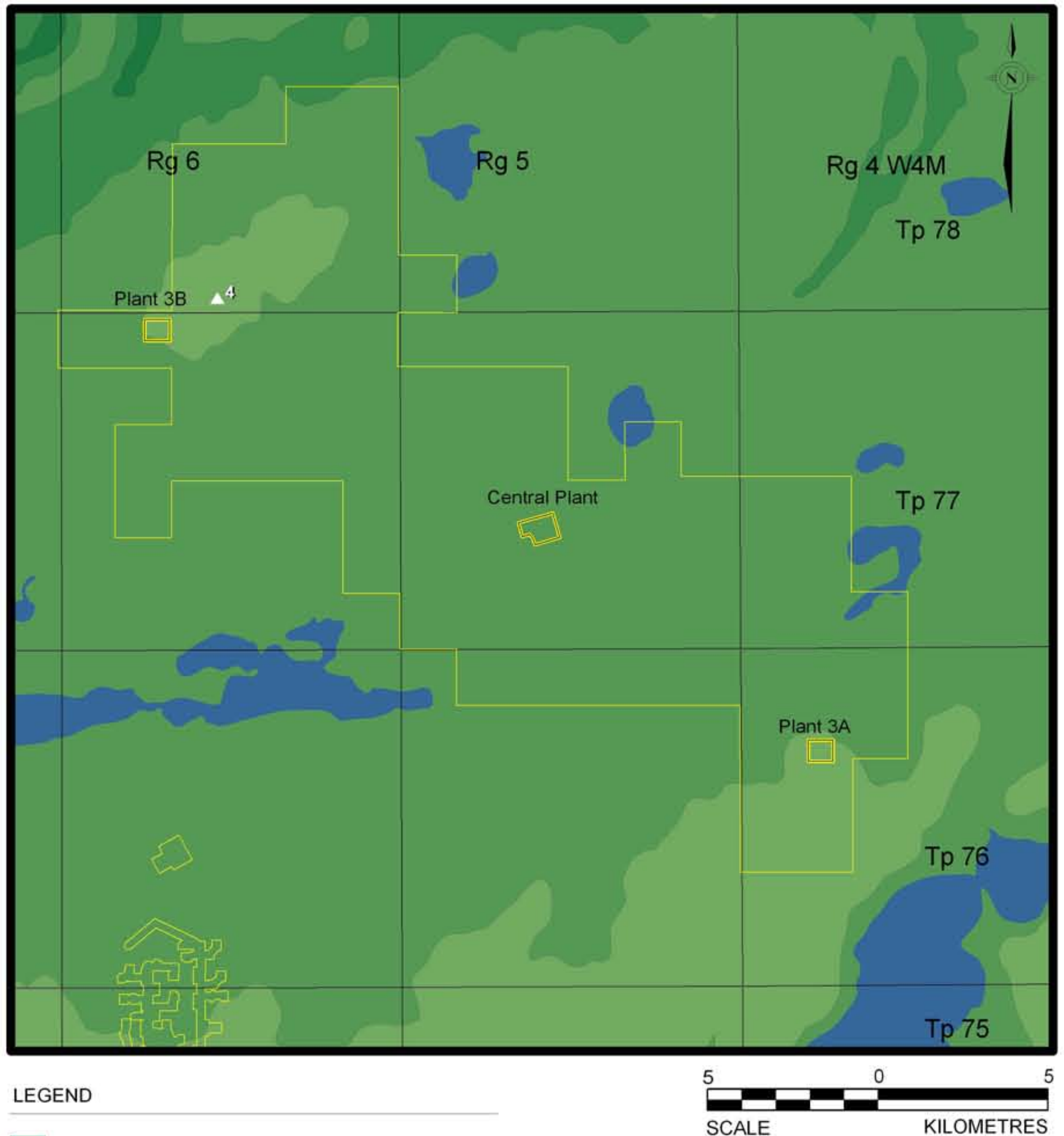
FIGURE: 11

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/BAS_NO2_a.srf

AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



SCALE: AS SHOWN

REFERENCE

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USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- 🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- 🟩 *MEG PLANTSITES*
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- ▲ *MAXIMUM PREDICTION WITHIN LSA.*
- △ *MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.*

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE
ANNUAL AVERAGE NO_2 PREDICTIONS

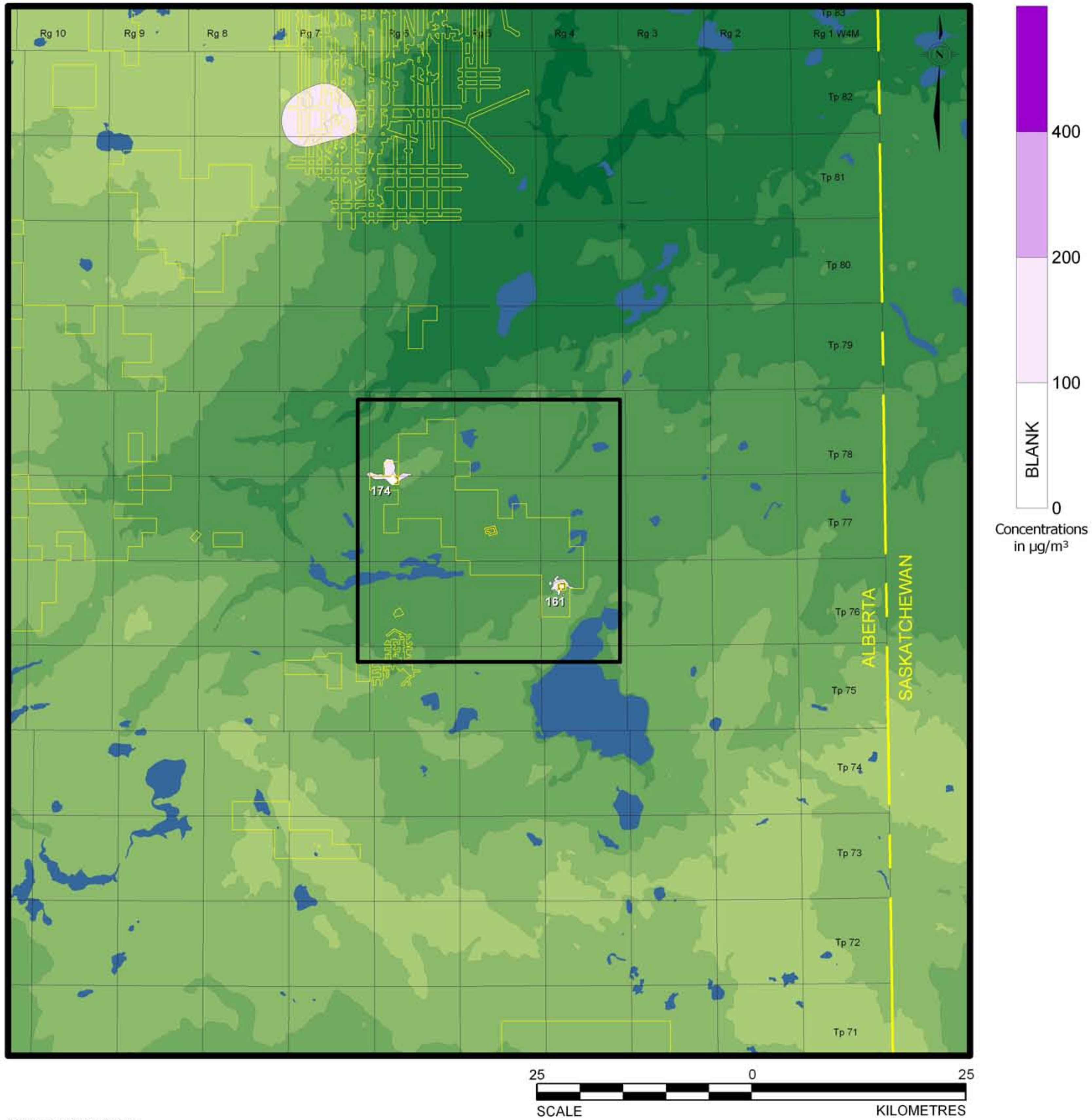
MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

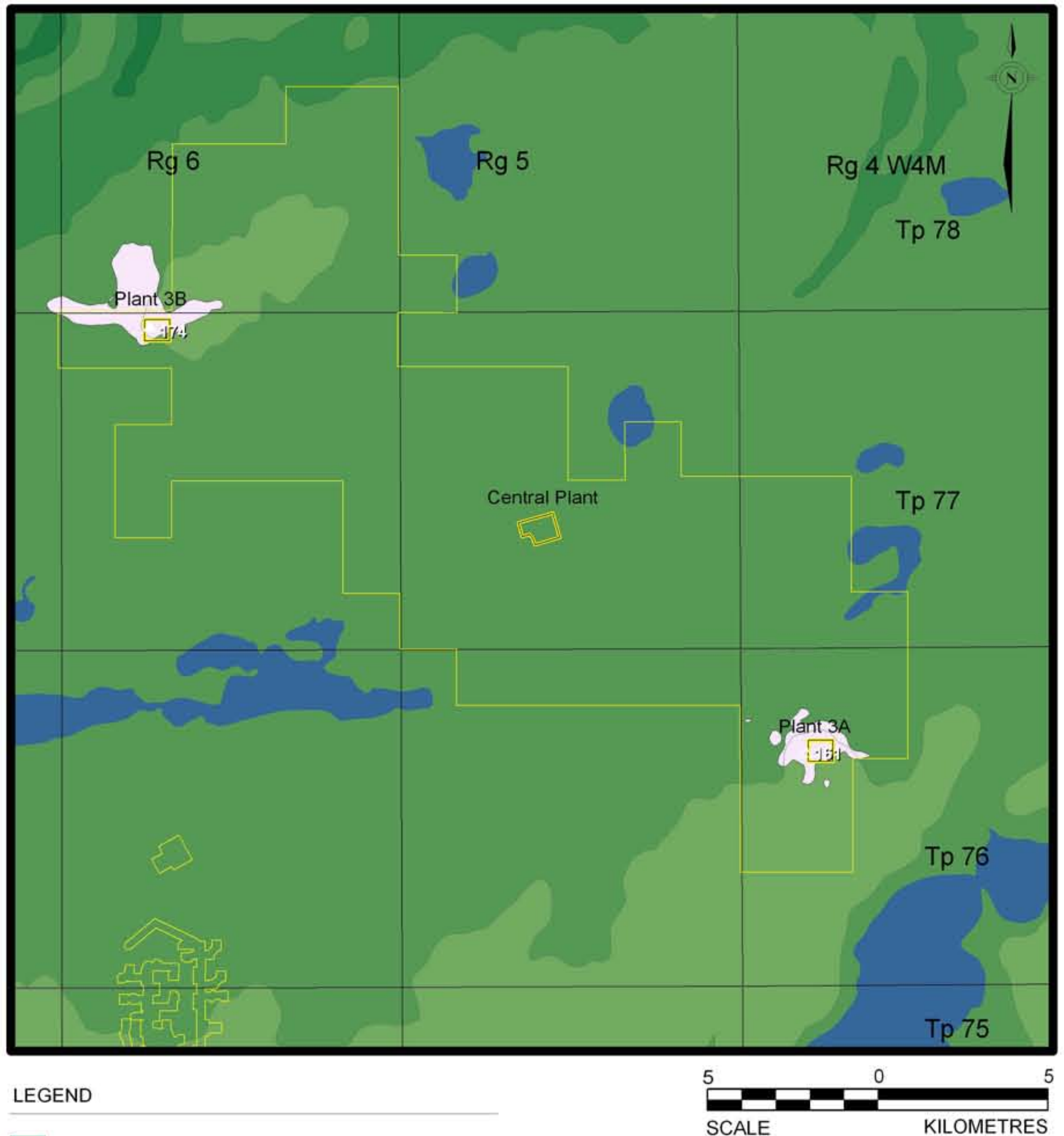
FIGURE: 12

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/APP_NO2_9th_hr.srf

AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.

MEG PLANTSITES

☐ *LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*

◆ *MAXIMUM PREDICTION WITHIN RSA.*

◇ *MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.*

▲ *MAXIMUM PREDICTION WITHIN LSA.*

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SCALE: AS SHOWN

REFERENCE

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USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE
MAXIMUM 1-HOUR NO_2 PREDICTIONS

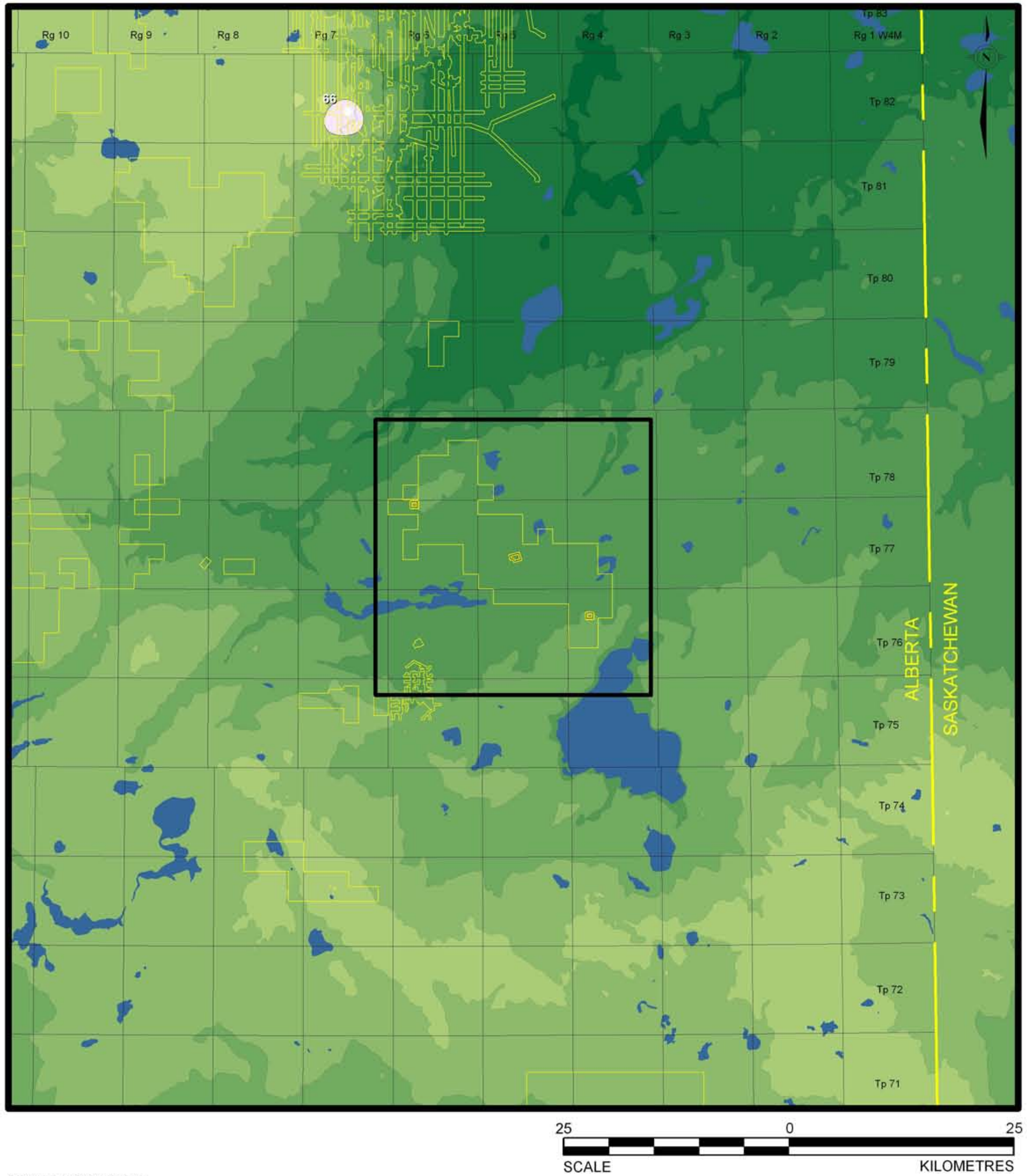
MEG ENERGY CORP.

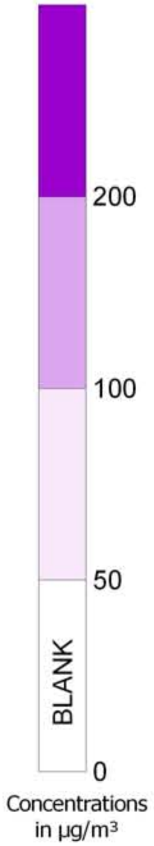
DESIGN	MS	06/02/08
AIR	REN	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 13

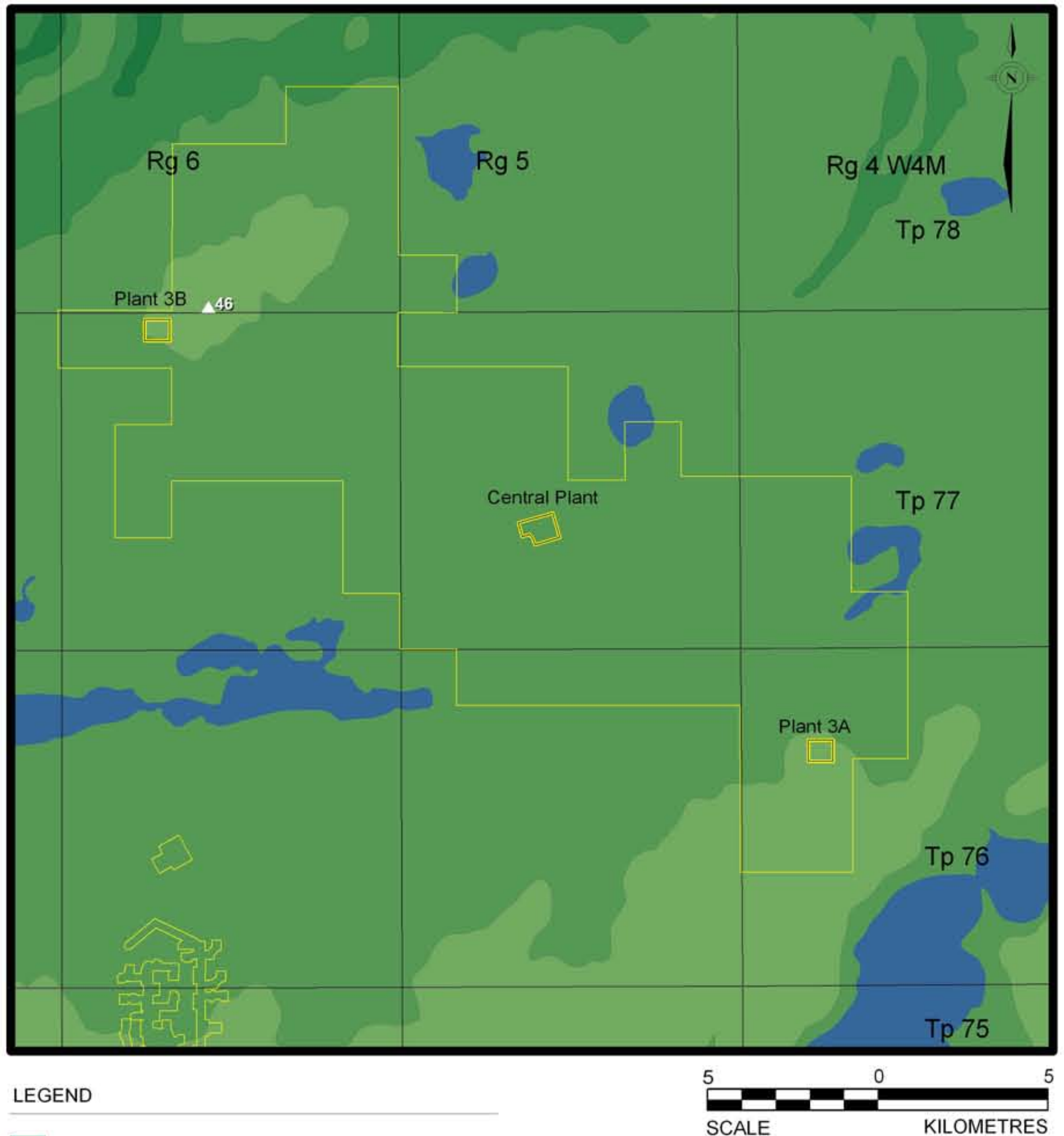
R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/APP_NO2_d.srf

AIR REGIONAL STUDY AREA





AIR LOCAL STUDY AREA



LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

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🟩 *MEG PLANTSITES*

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SCALE: AS SHOWN

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USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE
MAXIMUM 24-HOUR NO_2 PREDICTIONS

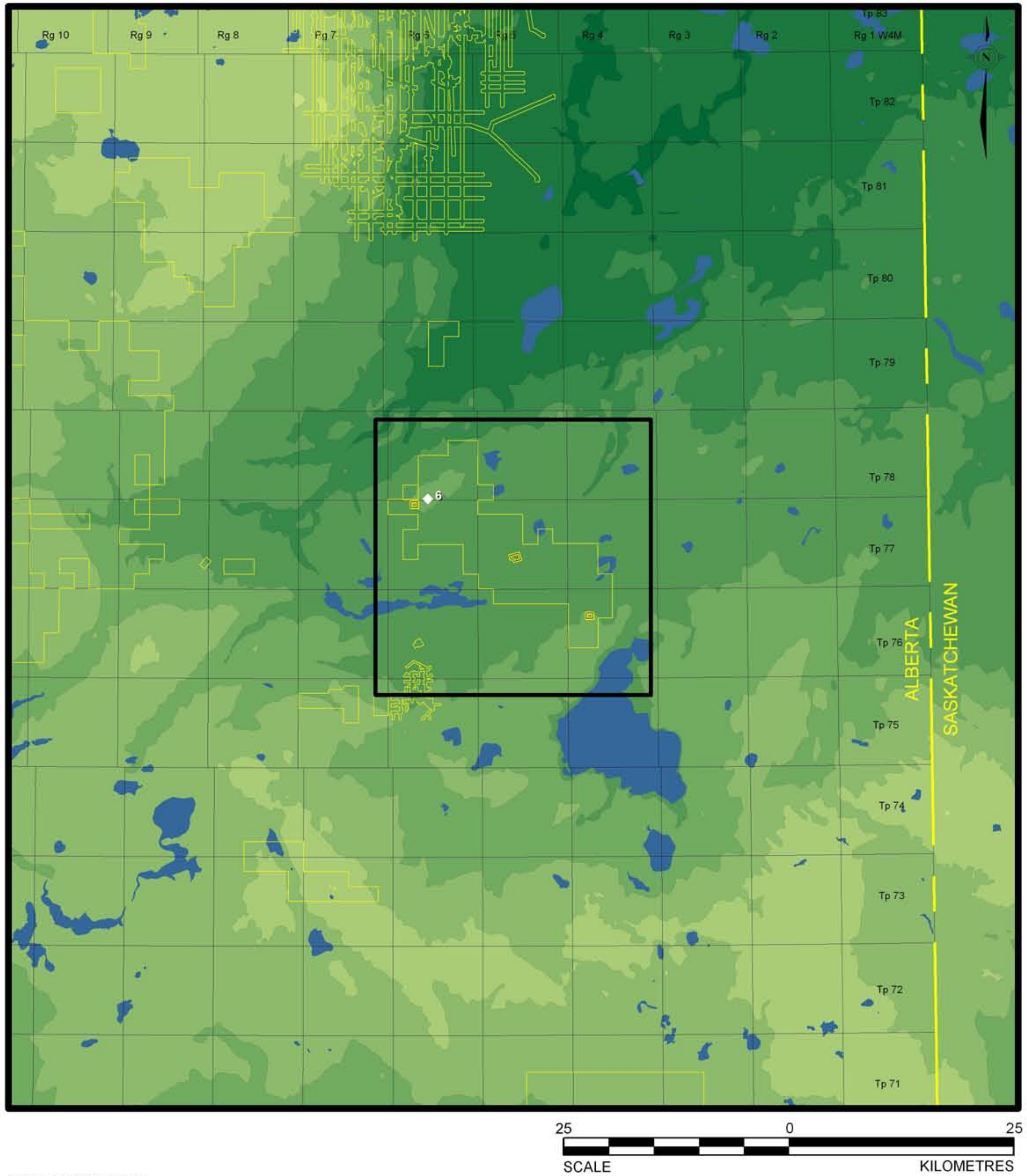
MEG ENERGY CORP.

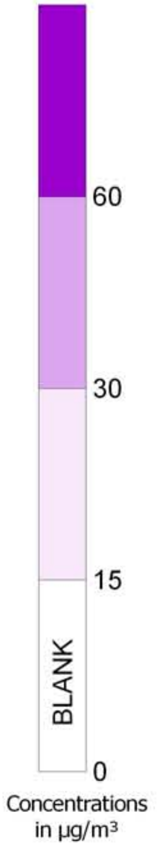
DESIGN	MS	06/02/08
AIR	REN	19/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 14

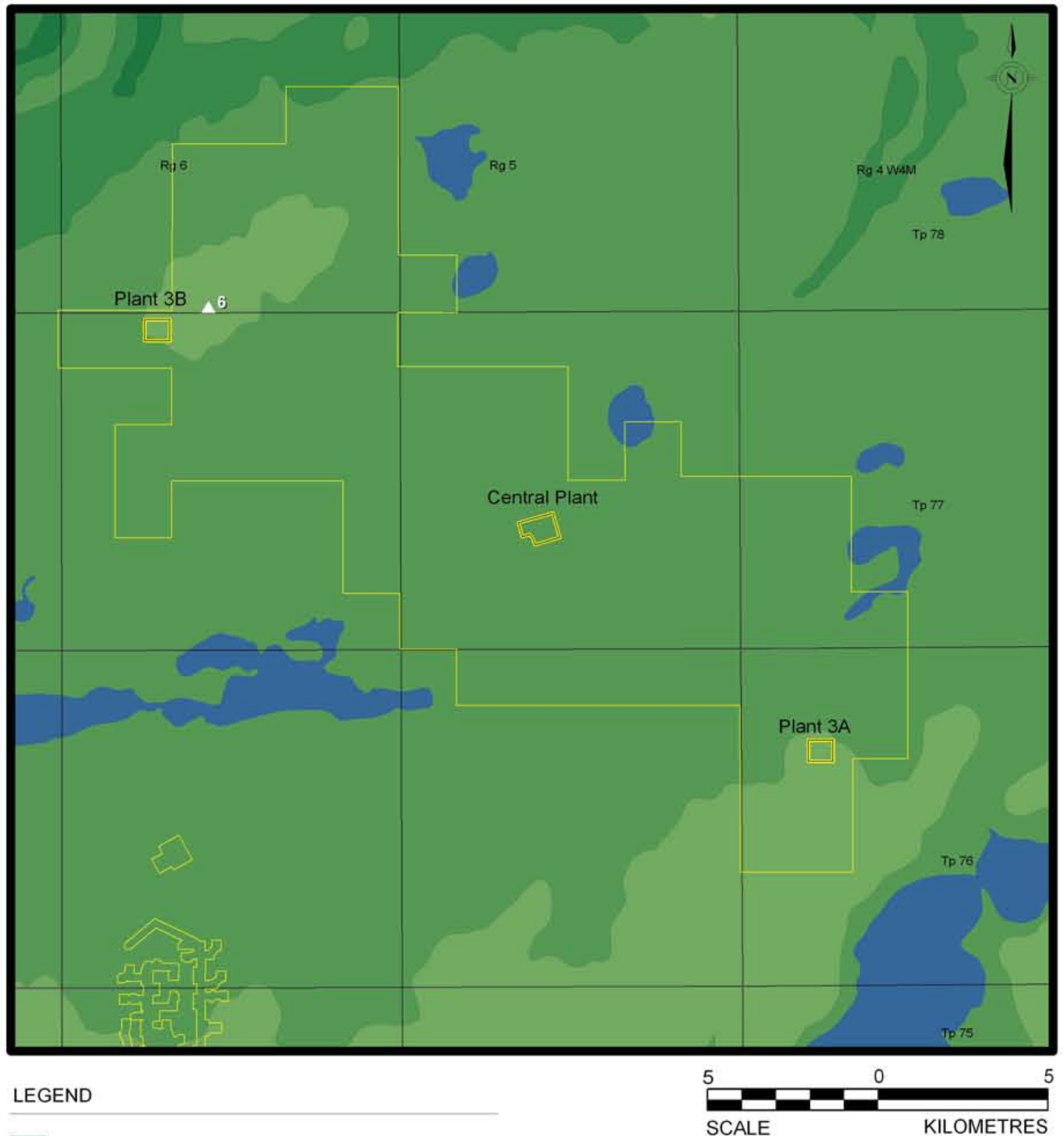
R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/APP_NO2_a.srf

AIR REGIONAL STUDY AREA





AIR LOCAL STUDY AREA



LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- 🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
- 🟩 *MEG PLANTSITES*
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SCALE: AS SHOWN

REFERENCE

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USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT
CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE
PROJECT CASE
ANNUAL AVERAGE NO_2 PREDICTIONS

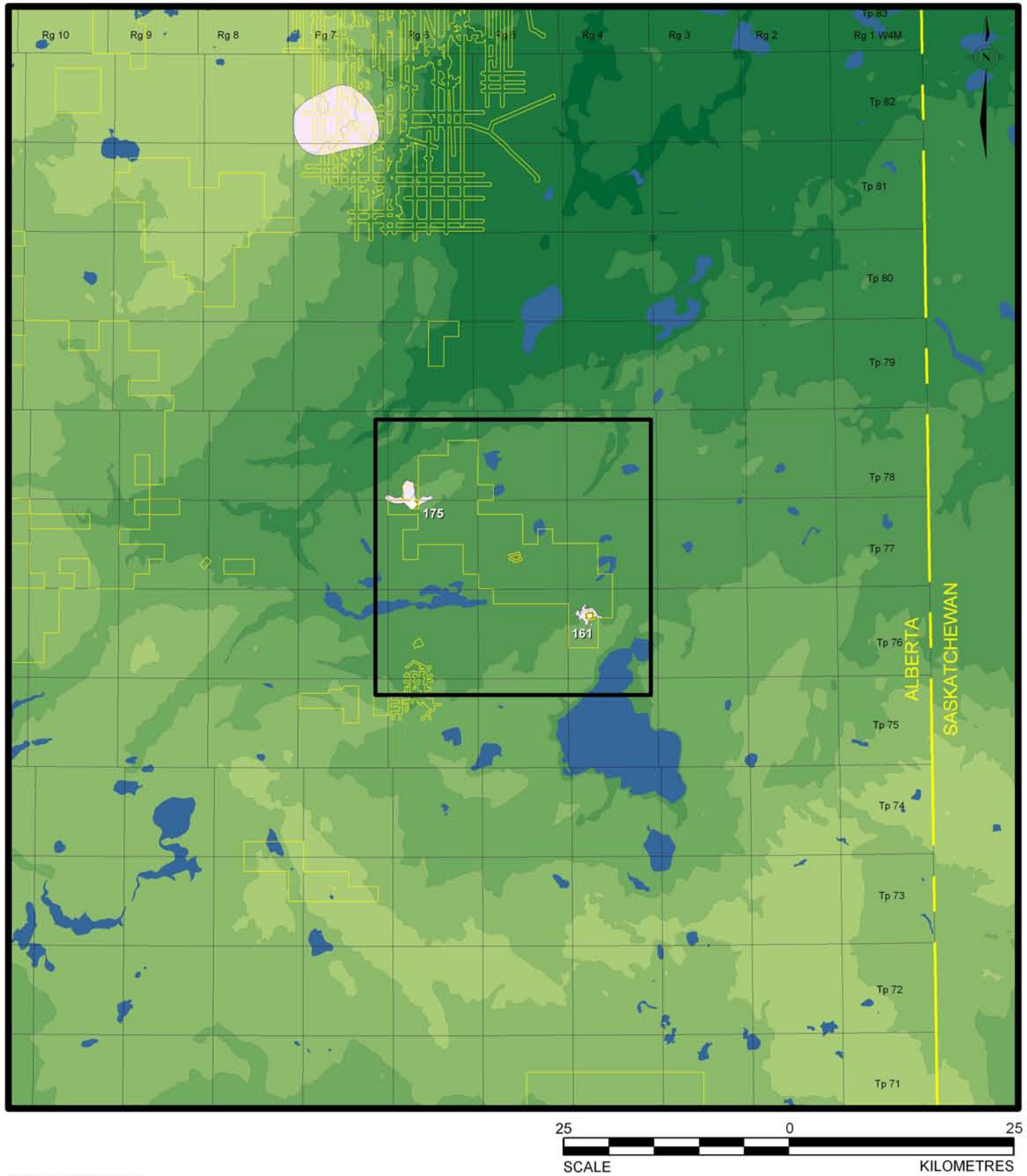
MEG ENERGY CORP.

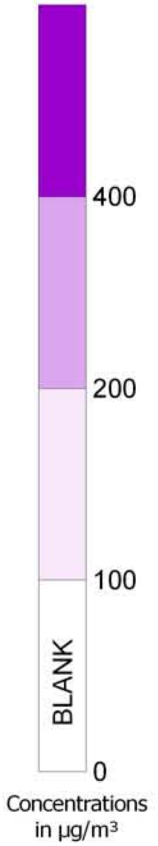
DESIGN	MS	06/02/08
AIR	REN	15/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 15

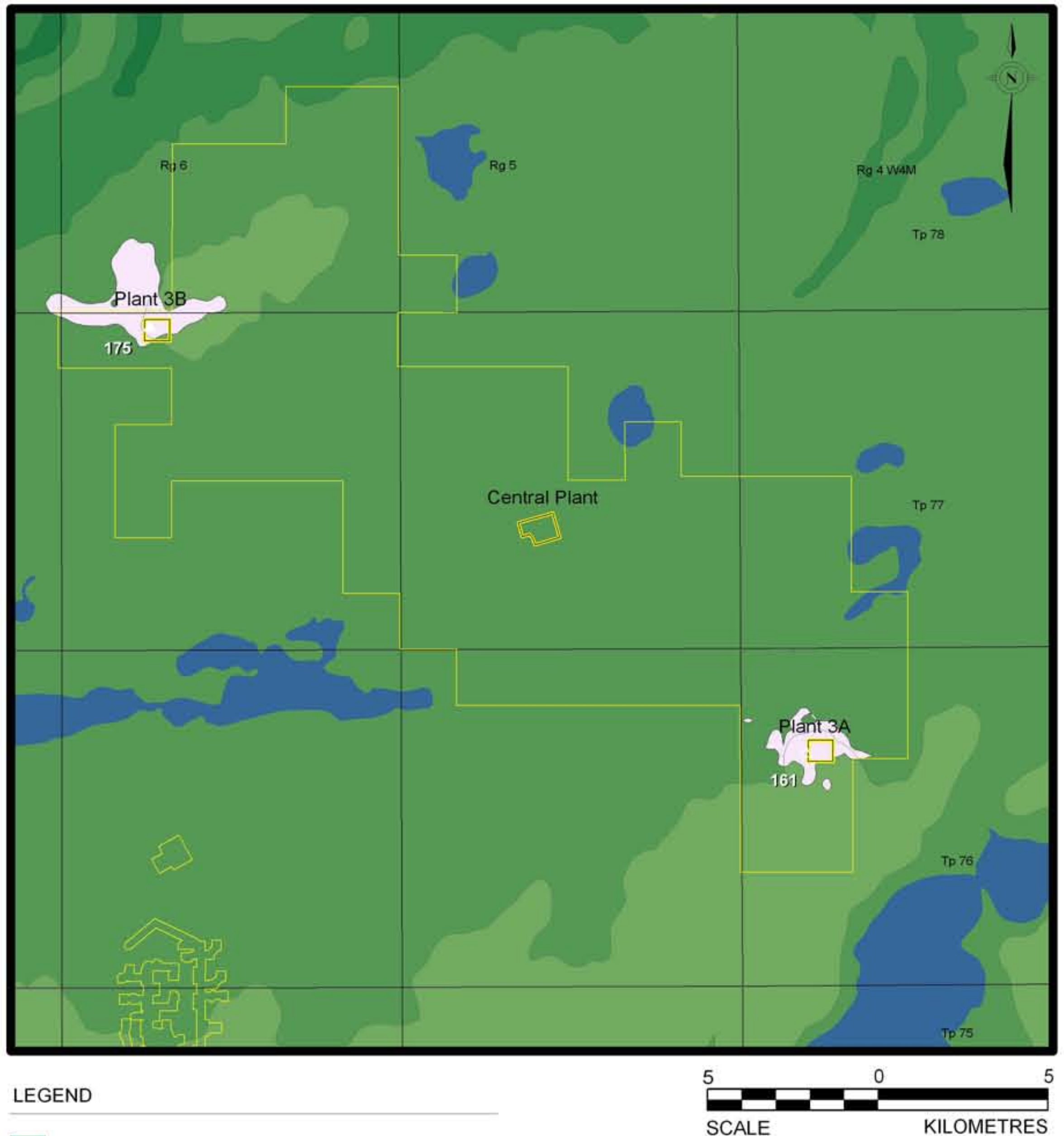
R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/PDC_NO2_9th_hr.srf

AIR REGIONAL STUDY AREA





AIR LOCAL STUDY AREA



LEGEND

- 🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
- 🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
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SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

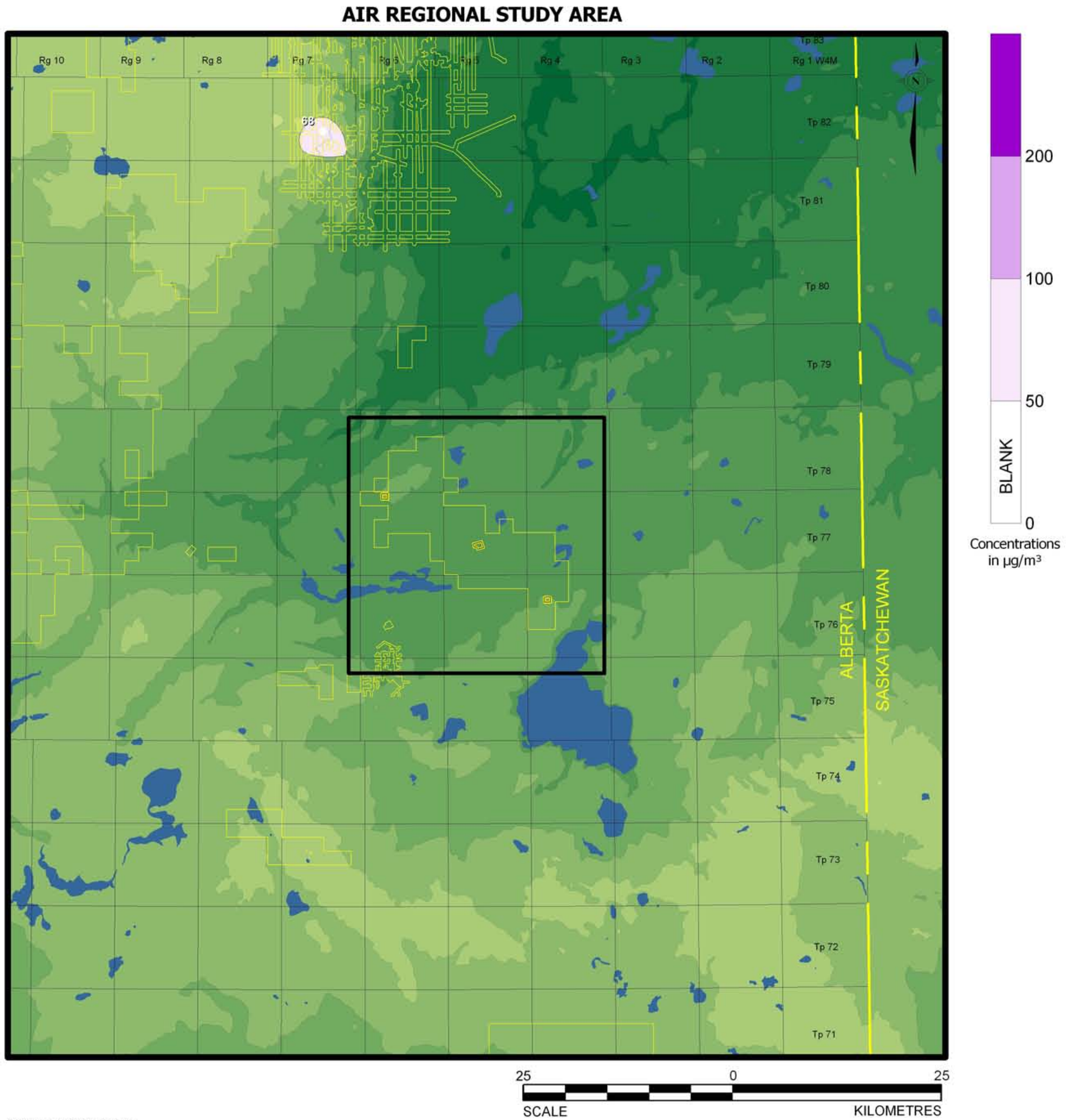
PLANNED DEVELOPMENT CASE
MAXIMUM 1-HOUR NO_2 PREDICTIONS

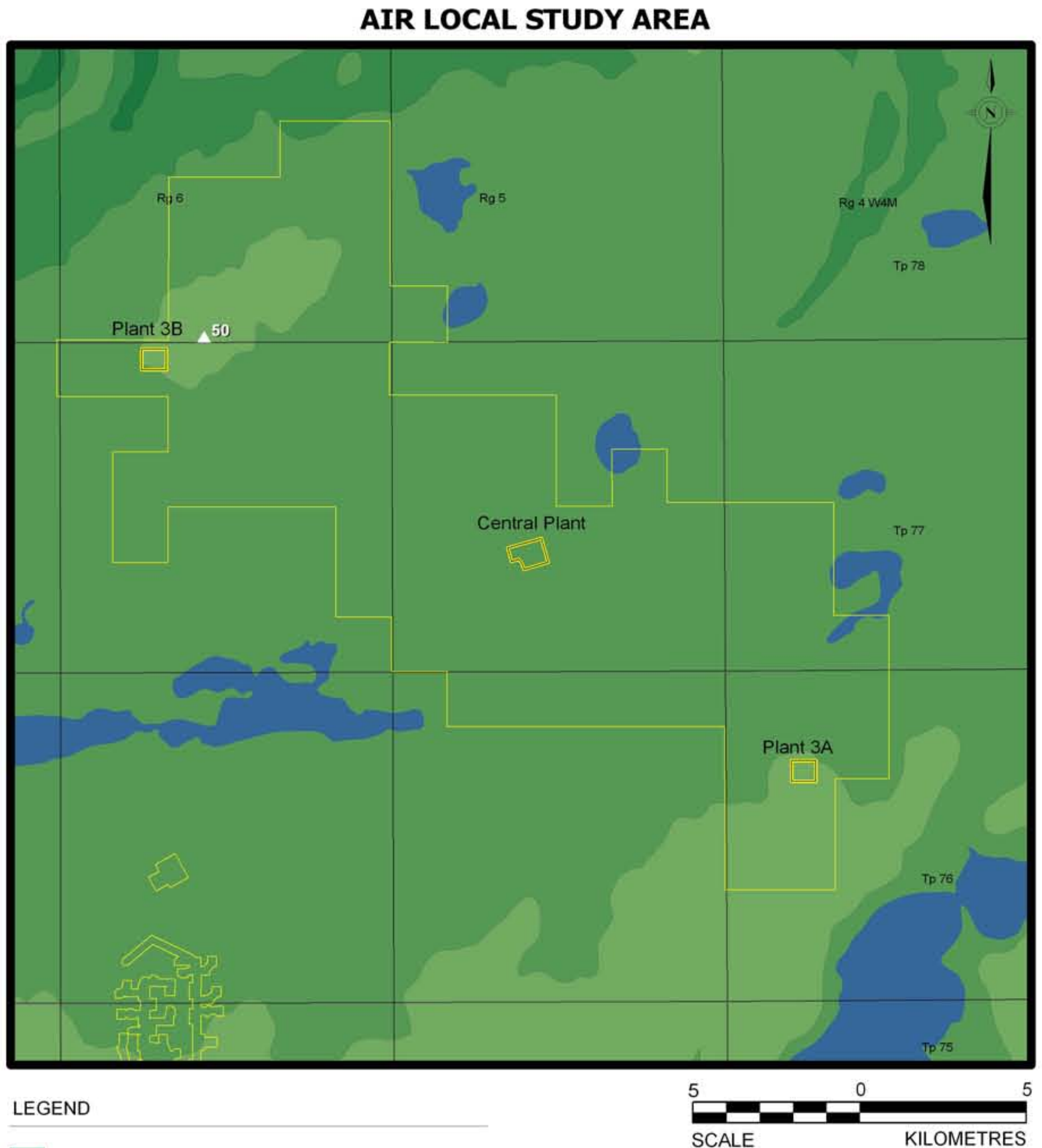
MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	15/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 16

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/PDC_NO2_d.srf





LEGEND

- 🟩 ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.
- MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.
- MEG PLANTSITES
- ☐ LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.
- ◆ MAXIMUM PREDICTION WITHIN RSA.
- ◇ MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.
- ▲ MAXIMUM PREDICTION WITHIN LSA.
- △ MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

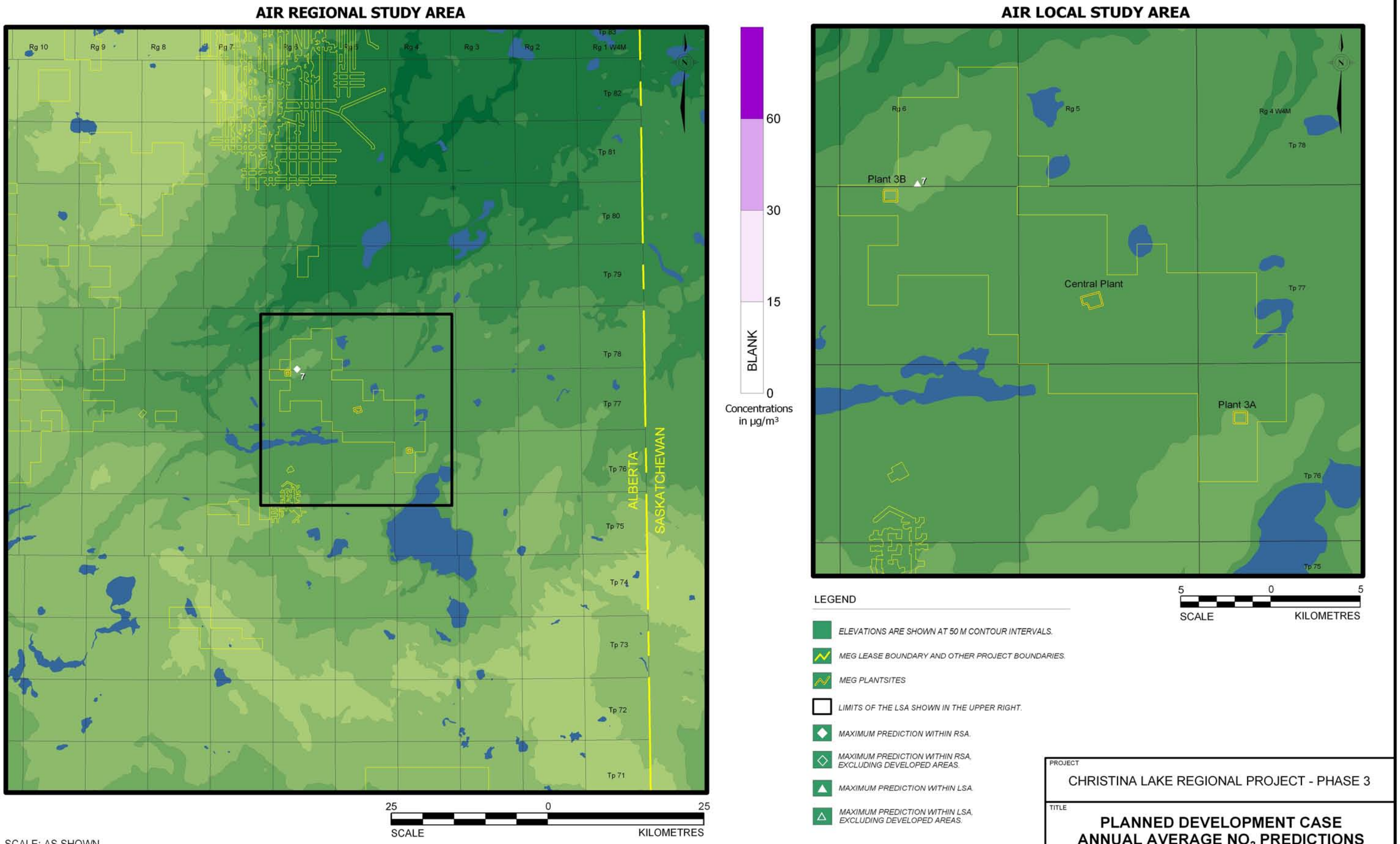
TITLE

PLANNED DEVELOPMENT CASE
MAXIMUM 24-HOUR NO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	15/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 17



LEGEND

🟩 ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.

🟩 MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.

🟩 MEG PLANTSITES

☐ LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.

◆ MAXIMUM PREDICTION WITHIN RSA.

◇ MAXIMUM PREDICTION WITHIN RSA, EXCLUDING DEVELOPED AREAS.

▲ MAXIMUM PREDICTION WITHIN LSA.

△ MAXIMUM PREDICTION WITHIN LSA, EXCLUDING DEVELOPED AREAS.

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PLANNED DEVELOPMENT CASE ANNUAL AVERAGE NO_2 PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	REN	15/02/08
CHECK	GH	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 18

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/PDC_NO2_a.srf

1.5 POTENTIAL ACID INPUT PREDICTIONS

Potential Acid Input (PAI) is the preferred method for evaluating the overall effects of acid-forming chemicals on the environment as it accounts for the acidifying effect of sulphur and nitrogen species, as well as the neutralizing effect of available base cations. The CALPUFF model was used to predict PAI in the region because it takes into account the chemical transformations of the emitted SO_2 and NO_X. CALPUFF also models both wet (i.e., rain and snow scavenged) and dry (i.e., via an effective dry deposition velocity) deposition of (sulphate) SO_2, SO_4^{2-}, NO, NO_2, NO_3^- and nitric acid (gas) (HNO_3).

The CALPUFF model PAI estimations were combined with the applicable background PAI values determined by Alberta Environment (AENV) (see Appendix 3-II, Section 2.3.8). The spatial extent of the predicted PAI levels shown in Figures 19, 20 and 21 for the EAC, Project Case and PDC, respectively, is summarized in Table 3. Table 4 summarizes the maximum predicted PAI levels, in conjunction with the highest nitrate and sulphate contributions to PAI for each case. These results indicate the following:

- **Existing and Approved Case**: PAI exceeds 0.17 keq/ha/yr over an area of 101,721 ha (7.7% of the RSA excluding developed areas) and exceeds 0.25 keq/ha/yr over 1,396 ha (0.1% of the RSA excluding developed areas). No areas are predicted to receive PAI in excess of 0.5 keq/ha/yr.
- **Project Case**: PAI exceeds 0.17 keq/ha/yr, 0.25 keq/ha/yr and 0.50 keq/ha/yr over an area of 148,544 ha (11.3% of the RSA excluding developed areas), 3,103 ha (0.2% of the RSA excluding developed areas) and 31 ha (0.002% of the RSA excluding developed areas), respectively. No areas are predicted to receive PAI in excess of 1.0 keq/ha/yr.
- **Planned Development Case**: PAI exceeds 0.17 keq/ha/yr, 0.25 keq/ha/yr and 0.50 keq/ha/yr over an area of 539,814 ha (40.9% of the RSA excluding developed areas), 9,520 ha (0.7% of the RSA excluding developed areas), and 38 ha (0.003% of the RSA excluding developed areas), respectively. No areas are predicted to receive PAI in excess of 1.0 keq/ha/yr.

It should be noted that Table 3 only presents areas where predicted PAI levels exceed certain levels. The table does not take into account the sensitivity of the receiving environment. An evaluation of areas where predicted PAI may affect the receiving environment is addressed in the Air Emission Effects on Ecological Receptors Assessment (Section 4).

Table 3 Existing and Approved Case, Project Case and Planned Development Case Spatial Extent for Predicted Potential Acid Input Values

PAI Level [keq/ha/yr]	Area Excluding Developed Areas[a] [ha]		
	EAC	Project Case	PDC
Local Study Area			
0.17	21,521	43,491	80,740
0.25	1,396	3,095	4,310
0.50	0	31	38
1.00	0	0	0
Regional Study Area			
0.17	101,721	148,544	539,814
0.25	1,396	3,103	9,520
0.50	0	31	38
1.00	0	0	0

[a] Developed areas include the Project plant sites.

Table 4 Existing and Approved Case, Project Case and Planned Development Case Maximum Predicted Acid-Forming Deposition

Parameter	Maximum Annual Deposition [keq/ha/yr]		
	EAC	Project Case	PDC
Local Study Area			
PAI	0.44	0.69	0.71
PAI (excluding developed areas)	0.42	0.68	0.69
nitrate deposition (excluding developed areas)	0.26	0.33	0.35
sulphate deposition (excluding developed areas)	0.20	0.44	0.44
Regional Study Area			
PAI	0.44	0.69	0.71
PAI (excluding developed areas)	0.42	0.68	0.69
nitrate deposition (excluding developed areas)	0.26	0.33	0.35
sulphate deposition (excluding developed areas)	0.20	0.44	0.44

Note: The maximum nitrate and sulphate deposition values do not include background values and are not necessarily co-located. Therefore, the addition of the maximum nitrate and maximum sulphate will not necessarily add up to the highest total PAI value listed in the table.

The Clean Air Strategic Alliance (CASA) framework for managing acid deposition in Alberta considers management units represented by grid cells that are 1° by 1° in size. The centre of each grid cell corresponds with the intersection of whole lines of latitude and lines of longitude. The modelling domain for the Project air assessment overlays 25 of these grid cells, all of which are classified as sensitive to acid inputs. Using the modelling results, the PAI values corresponding to each of the twenty-five 1° by 1° grid cells were determined for each case. These results are presented in Table 5.

The table indicates that the predicted PAI levels in grid cells 57º by 111º and 57º by 112º are higher than the 0.25 keq/ha/yr critical load for sensitive ecosystems. These two grid cells are located about 150 km NNW of the Project and contain the majority of the oil sands development in the region, including the approved open pit mining operations. The Project is located in grid cell 56º by 111º, which is expected to experience PAI levels above the monitoring load of 0.17 keq/ha/yr in the PDC.

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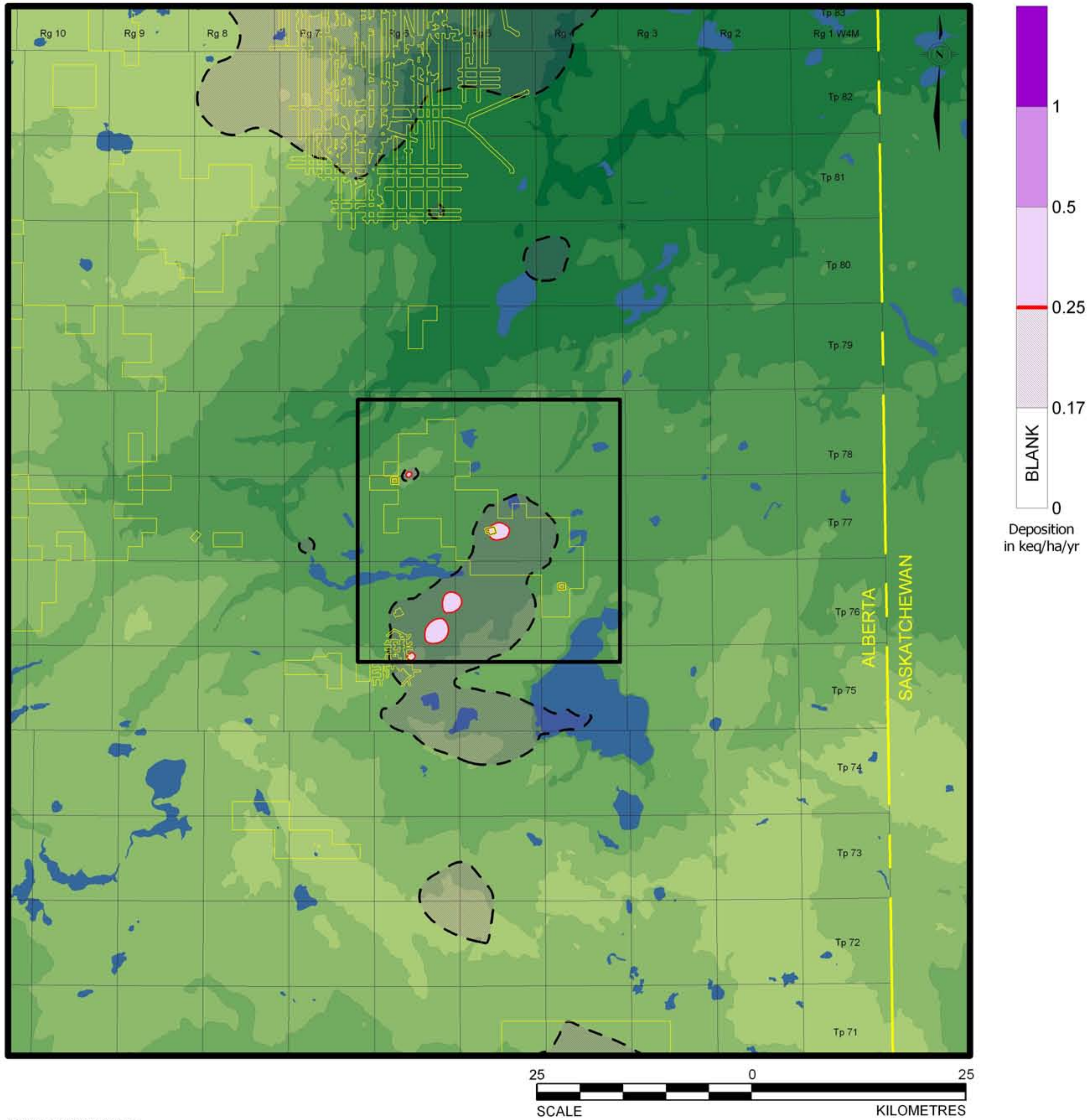
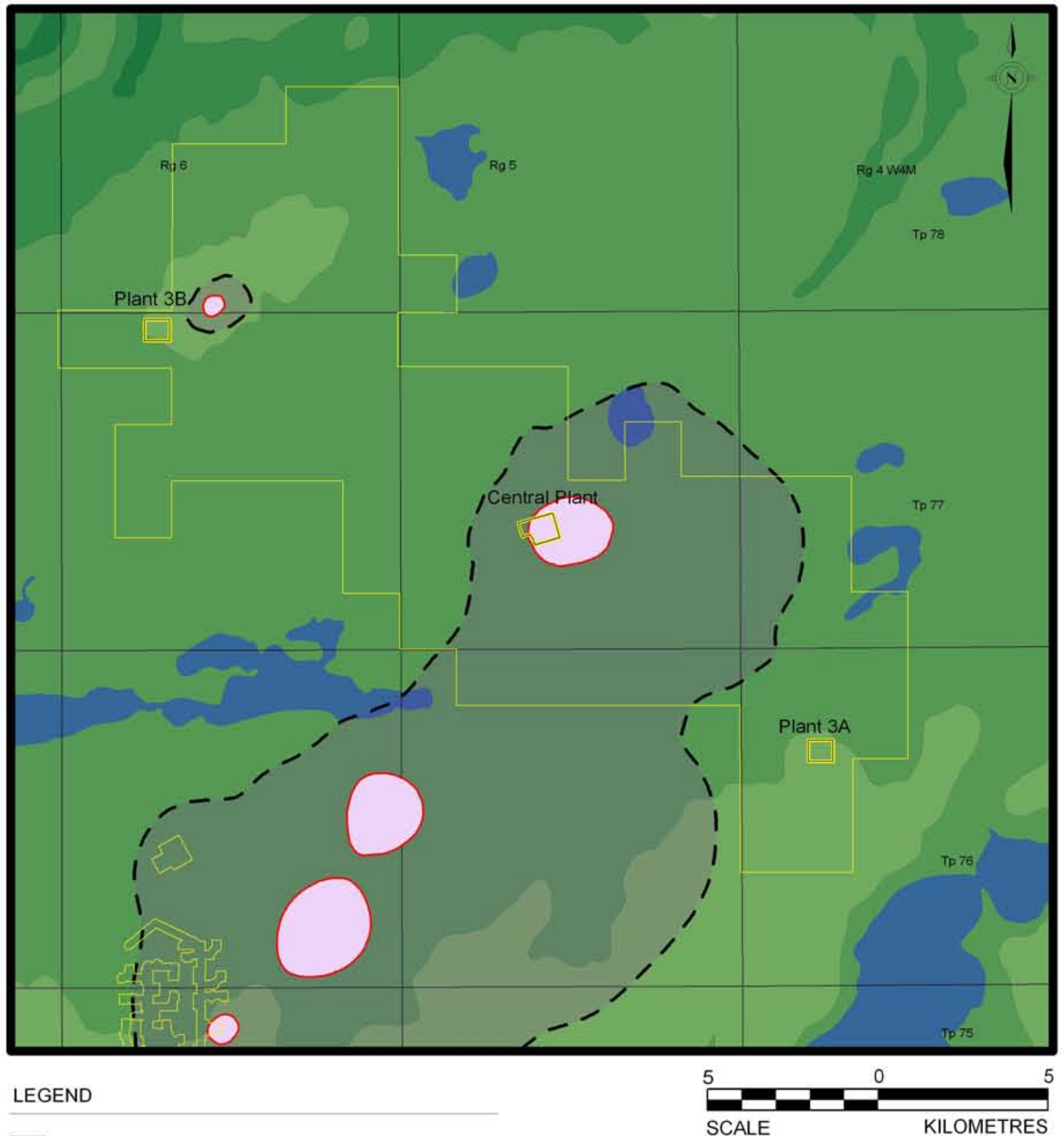
AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

- 🟩 ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.
- 🟩 MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.
- 🟩 MEG PLANTSITES
- ☐ LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

EXISTING AND APPROVED CASE POTENTIAL ACID INPUT (PAI) PREDICTIONS

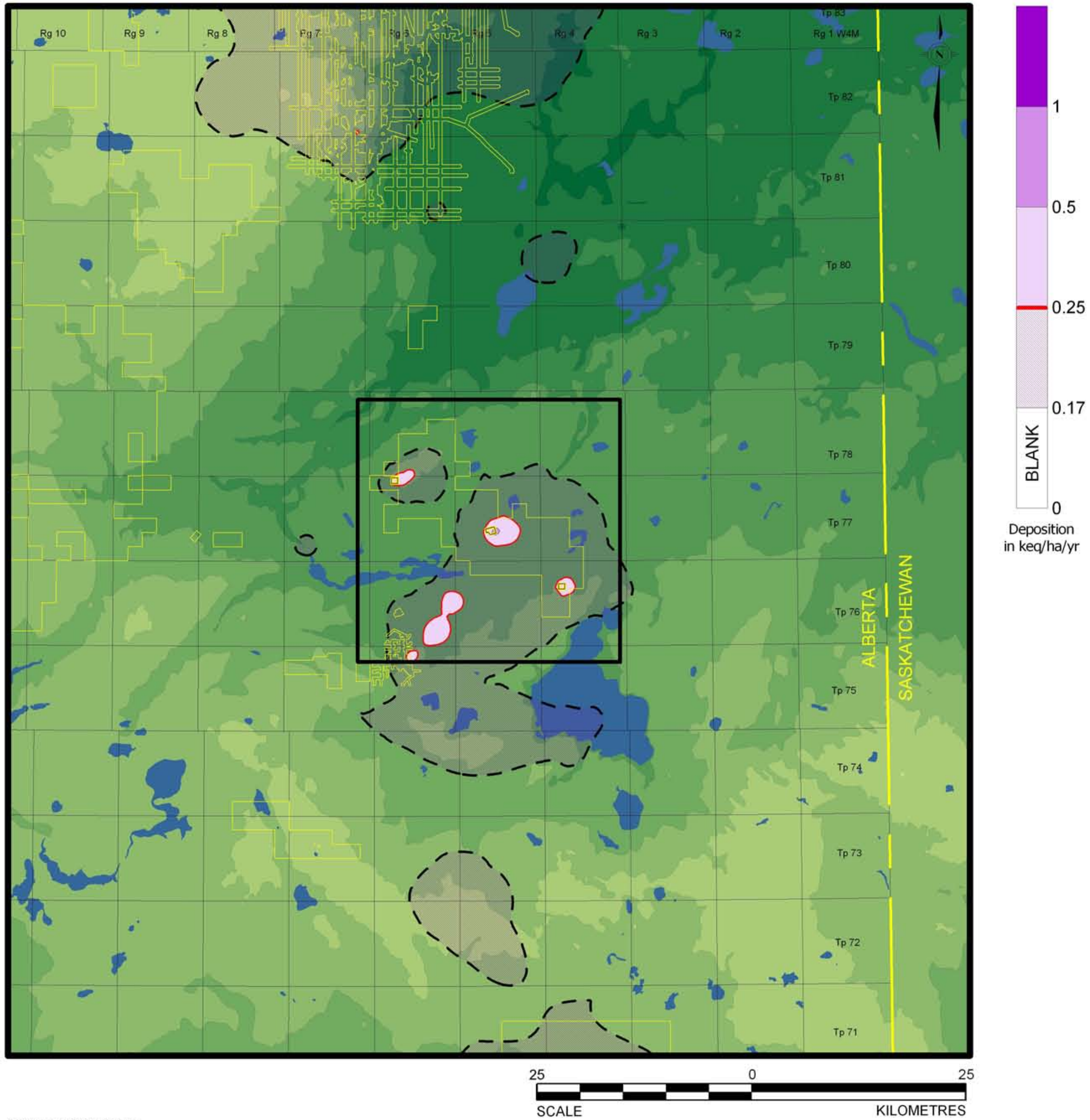
MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	GH	19/02/08
CHECK	REN	19/02/08
REVIEW	IGG	09/04/08

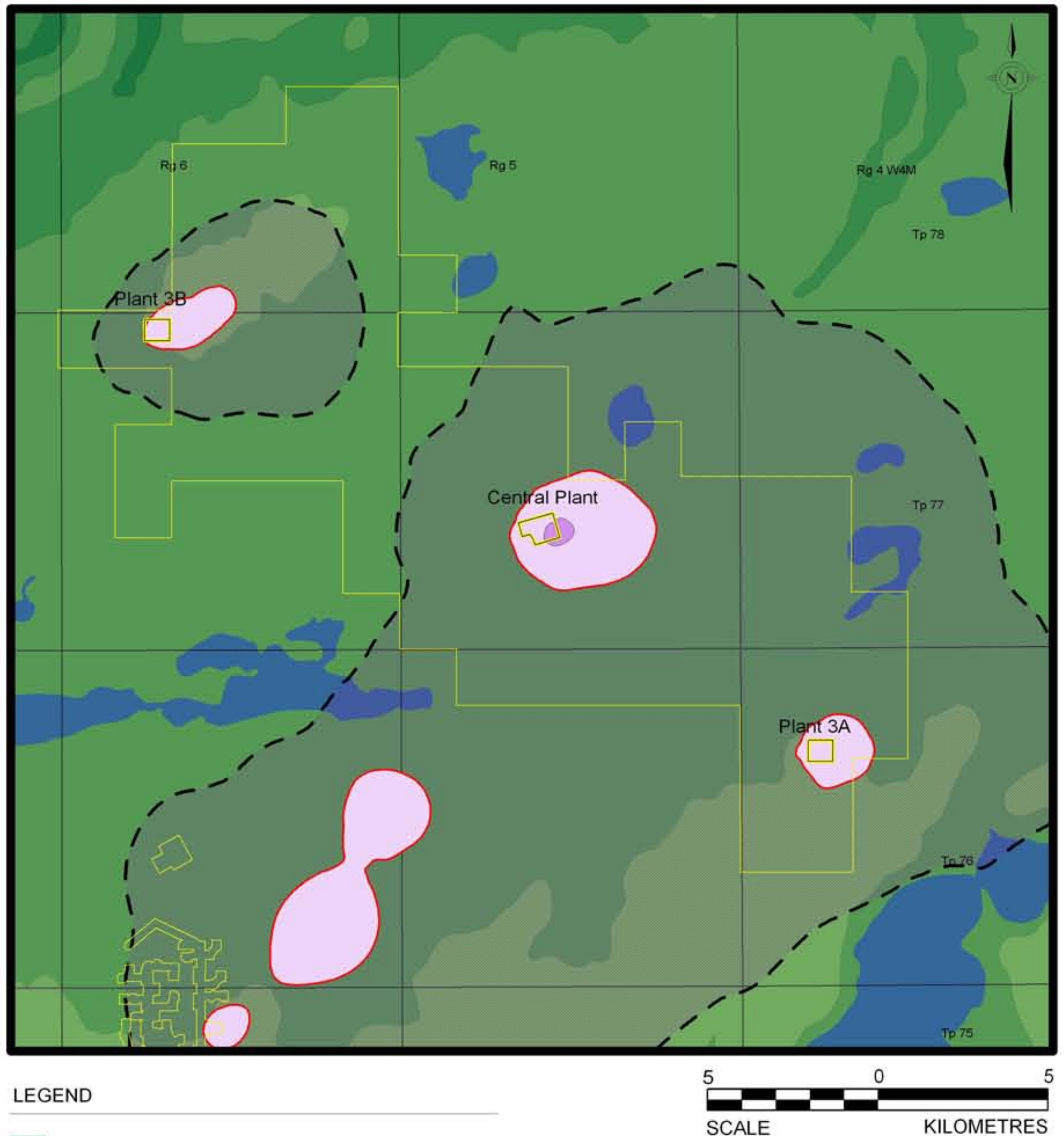
FIGURE: 19

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/APP_PAI.srf

AIR REGIONAL STUDY AREA



AIR LOCAL STUDY AREA



LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*

🟩 *MEG PLANTSITES*

☐ *LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PROJECT CASE
POTENTIAL ACID INPUT (PAI) PREDICTIONS

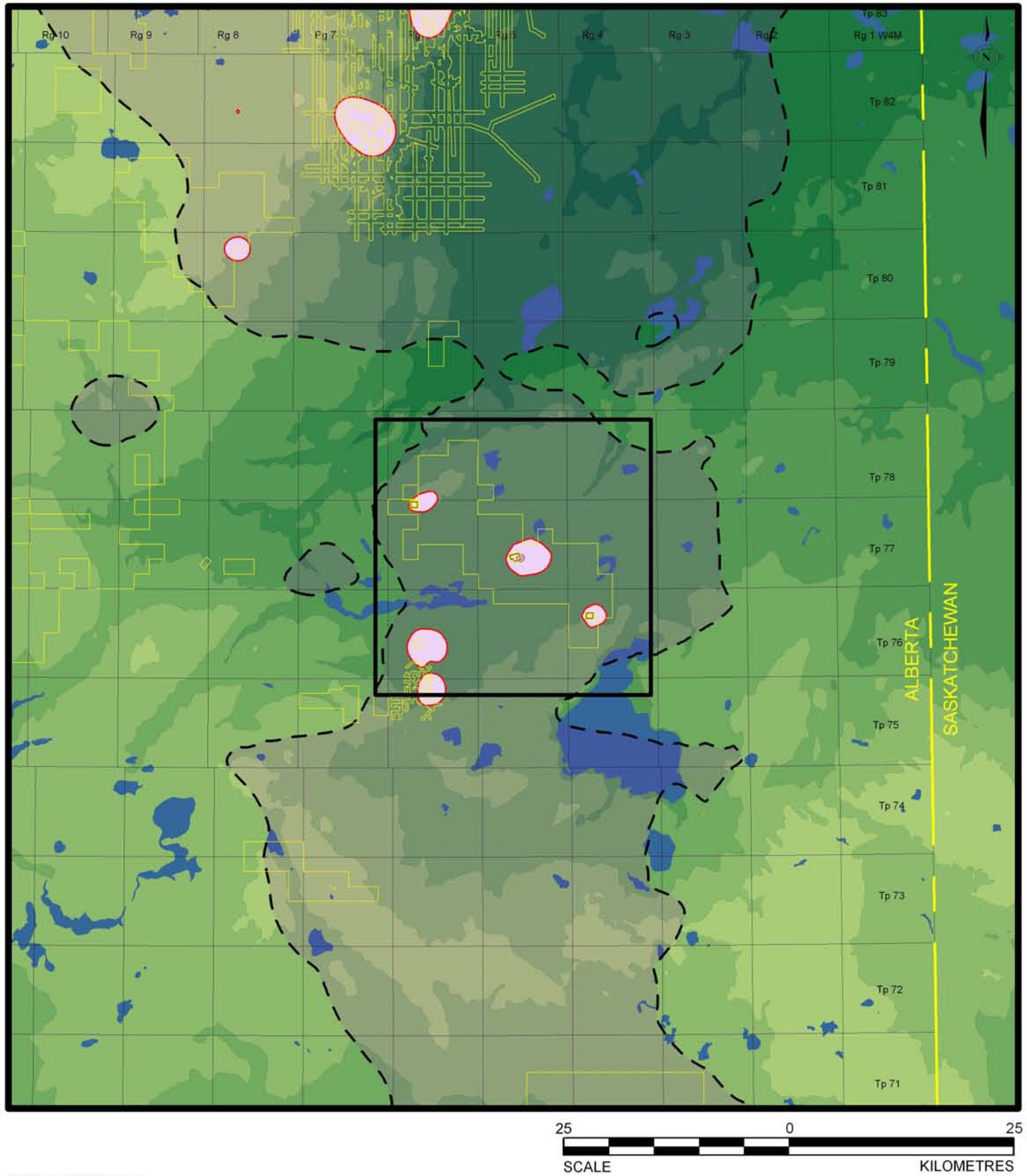
MEG ENERGY CORP.

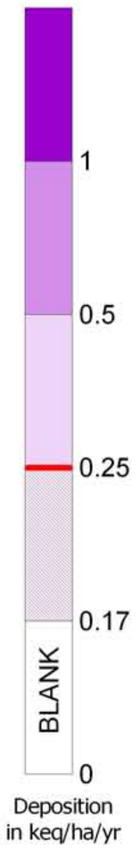
DESIGN	MS	06/02/08
AIR	GH	19/02/08
CHECK	REN	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 20

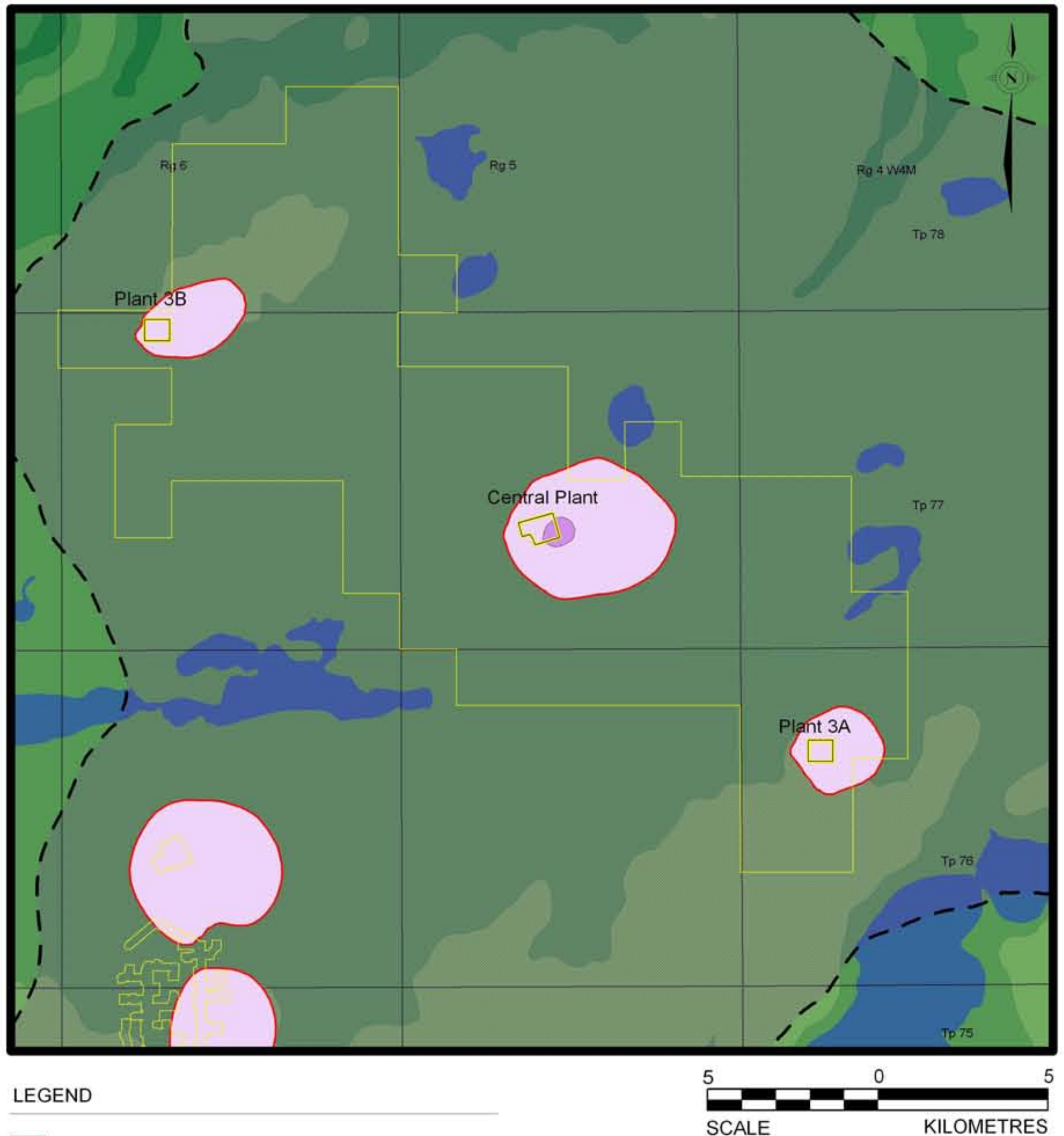
R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/PDC_PAI.srf

AIR REGIONAL STUDY AREA





AIR LOCAL STUDY AREA



LEGEND

🟩	*ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*
🟩	*MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES.*
🟩	*MEG PLANTSITES*
☐	*LIMITS OF THE LSA SHOWN IN THE UPPER RIGHT.*

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

PLANNED DEVELOPMENT CASE POTENTIAL ACID INPUT(PAI) PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	06/02/08
AIR	GH	19/02/08
CHECK	REN	19/02/08
REVIEW	IGG	09/04/08

FIGURE: 21

Table 5 Existing and Approved Case, Project Case and Planned Development Case Potential Acid Input Predictions for 1° by 1° Grid Cells

Grid Cell Centre(a)	1995 Background(b) [keq/ha/yr]	EAC(c) [keq/ha/yr]	Project Case(c) [keq/ha/yr]	PDC(c) [keq/ha/yr]
58º×113º	0.040	0.062	0.062	0.067
58º×112º	0.033	0.076	0.076	0.089
58º×111º	0.030	0.110	0.110	0.140
58º×110º	0.024	0.070	0.070	0.082
58º×109º	0.030	0.056	0.056	0.063
57º×113º	0.054	0.091	0.091	0.101
57º×112º	0.047	0.330	0.330	0.405
57º×111º	0.043	0.341	0.341	0.388
57º×110º	0.044	0.118	0.118	0.138
57º×109º	0.044	0.086	0.086	0.097
56º×113º	0.075	0.107	0.107	0.116
56º×112º	0.060	0.112	0.113	0.131
56º×111º(d)	0.065	0.161	0.165	0.200
56º×110º	0.062	0.127	0.130	0.149
56º×109º	0.062	0.101	0.102	0.112
55º×113º	0.117	0.132	0.132	0.136
55º×112º	0.102	0.128	0.129	0.134
55º×111º	0.099	0.158	0.160	0.169
55º×110º	0.092	0.153	0.155	0.162
55º×109º	0.073	0.102	0.103	0.109
54º×113º	0.163(e)	0.167	0.167	0.168
54º×112º	0.140(e)	0.151	0.151	0.153
54º×111º	0.080(e)	0.102	0.102	0.104
54º×110º	0.075(e)	0.097	0.098	0.100
54º×109º	0.068(e)	0.085	0.086	0.088

(a) The 1° by 1° grid cells are centred on the listed latitude and longitude.

(b) Background PAI values were determined by Alberta Environment (AENV) using the Regional Lagrangian Acid Deposition Model (RELAD) model (Cheng 2001), except where noted.

(c) The EAC, Project Case and PDC predictions include the background PAI predicted by AENV.

(d) The Project is located in grid cell 56º by 111º.

(e) Background PAI values were determined by AENV using the RELAD model (Cheng 2005).

The deposition of acid-forming compounds can have an effect on terrestrial or aquatic ecosystems that are not well buffered. An evaluation of possible effects that could result from the acid deposition on the receiving environment is provided in the Air Emission Effects on Ecological Receptors Assessment (Section 4).

1.6 SELECTED RECEPTORS EXPOSURE LEVELS

In modelling the emissions from the EAC, Project Case and PDC, ambient air quality concentrations were predicted at the selected receptors described in Section 1.2. These include one community and two locations in Alberta that are of importance to First Nations groups and represent the primary population centres in the region that could potentially experience increased concentrations due to the Project. In addition, concentrations were predicted at two cabins, the Operator's Residence, the Christina Lake Lodge and along the maximum property boundary where persons could experience prolonged exposure to air emissions. In addition, La Loche, Saskatchewan was modelled to assess the transboundary effects of the Project.

1.6.1 Sulphur Dioxide (SO_2) Predictions

Tables 6 and 7 summarize the ground-level SO_2 concentrations estimated for the EAC, Project Case and PDC at the selected receptors and the Saskatchewan receptor. The modelling results indicate that, with the exception of the peak 1-hour SO_2 concentration at the Maximum Property Boundary, the 1-hour, 24-hour and annual ground-level SO_2 concentrations at the selected receptors and the Saskatchewan receptor are below the respective AAAQOs of 450, 150 and 30 µg/m³. As per AENV (2003), compliance with AAAQOs is determined based on the maximum ground-level 1-hour concentration, which excludes the eight highest 1-hour predictions. Consequently, the maximum 1-hour SO_2 concentration at the Maximum Property Boundary is below the AAAQO. Several of the SO_2 predictions decreased from the Project Case to the PDC. This change is attributed to the expected decrease in SO_2 emissions from the EnCana FCCL Oil Sands Ltd. (EnCana) Christina Lake Thermal Project in the PDC.

Table 6 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Sulphur Dioxide Predictions at Selected Receptors

Receptor	Peak 1-Hour SO_2[a][b]			Maximum 1-Hour SO_2[b][c]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	35.8	36.6	32.4	17.3	17.8	19.5
Janvier/Chard (IR 194)	40.2	40.2	47.5	25.6	25.6	31.7
Winefred Lake (IR 194B)	22.5	23.6	27.2	18.4	19.0	20.1
Hunter/Trapper A	88.5	88.5	46.0	60.8	60.8	27.3
Hunter/Trapper B	34.9	44.0	38.8	22.8	24.7	25.4
Operator's Residence	88.1	88.2	45.8	46.4	46.4	35.0
Christina Lake Lodge	43.6	44.3	57.8	19.9	20.6	22.0
La Loche, SK	16.5	16.5	20.8	13.9	13.9	15.6
Maximum Property Boundary	487.4	817.0	817.3	281.6	416.1	416.3

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

(b) The 1-hour Alberta Ambient Air Quality Objective for SO_2 is 450 µg/m³.

(c) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003).

Table 7 Existing and Approved Case, Project Case and Planned Development Case 24-Hour and Annual Sulphur Dioxide Predictions at Selected Receptors

Receptor	Peak 24-Hour SO_2[(a)(b)]			Peak Annual Average SO_2[(a)(c)]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	9.3	9.9	12.2	1.16	1.20	1.36
Janvier/Chard (IR 194)	13.4	13.4	17.3	1.49	1.52	1.80
Winefred Lake (IR 194B)	10.4	11.3	14.1	1.68	1.82	1.79
Hunter/Trapper A	19.6	19.9	13.5	2.52	2.70	2.19
Hunter/Trapper B	12.0	12.0	15.6	1.40	1.46	1.69
Operator's Residence	23.8	23.8	13.7	2.51	2.78	2.32
Christina Lake Lodge	9.5	9.9	12.1	1.15	1.19	1.36
La Loche, SK	5.0	5.0	6.2	0.97	0.98	1.16
Maximum Property Boundary	66.0	118.5	119.8	6.53	15.63	15.53

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

(b) The 24-hour Alberta Ambient Air Quality Objective for SO_2 is 150 µg/m³.

(c) The annual Alberta Ambient Air Quality Objective for SO_2 is 30 µg/m³.

1.6.2 Nitrogen Dioxide (NO_2) Predictions

Tables 8 and 9 summarize the predicted NO_2 concentrations for the EAC, Project Case and PDC at the selected receptors and the Saskatchewan receptor. The modelling results indicate that, with the exception of the peak 1-hour NO_2 concentration at the Maximum Property Boundary for the Project Case and the PDC, the 1-hour, 24-hour and annual ground-level NO_2 concentrations at the selected receptors and the Saskatchewan receptor are below the respective AAAQOs of 400, 200 and 60 µg/m^3. As per AENV (2003), compliance with AAAQOs is determined based on the maximum 1-hour ground-level concentration, which excludes the eight highest 1-hour predictions. Consequently, the maximum 1-hour NO_2 concentration at the Maximum Property Boundary is below the AAAQO.

1.6.3 Carbon Monoxide (CO) Predictions

Table 10 summarizes the predicted CO concentrations for the EAC, Project Case and PDC at the selected receptors and the Saskatchewan receptor. The modelling results indicate that ground-level CO concentrations are below the 1-hour and 8-hour AAAQOs of 15,000 and 6,000 µg/m^3, respectively. The peak 1-hour CO concentration at the Operator's Residence dropped slightly from the Project Case to the PDC, and is likely due to the expected change in stack parameters at the EnCana Christina Lake Project in the PDC.

Table 8 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Nitrogen Dioxide Predictions at Selected Receptors

Receptor	Peak 1-Hour NO_2[a][b]			Maximum 1-Hour NO_2[b][c]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	136.0	136.1	143.9	84.4	84.4	87.6
Janvier/Chard (IR 194)	83.8	83.8	96.0	56.7	56.7	66.3
Winefred Lake (IR 194B)	38.6	72.6	75.4	20.6	54.1	59.5
Hunter/Trapper A	38.5	38.6	41.9	26.9	29.5	33.9
Hunter/Trapper B	35.6	41.1	47.8	29.9	31.3	39.0
Operator's Residence	56.0	56.0	56.0	31.1	31.8	37.7
Christina Lake Lodge	59.5	59.5	61.7	37.1	37.1	42.5
La Loche, SK	28.3	28.3	36.7	19.2	19.2	24.5
Maximum Property Boundary	326.6	572.6	574.0	84.8	156.1	157.4

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

(b) The 1-hour Alberta Ambient Air Quality Objective for NO_2 is 400 µg/m³.

(c) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003).

Table 9 Existing and Approved Case, Project Case and Planned Development Case 24-Hour and Annual Nitrogen Dioxide Predictions at Selected Receptors

Receptor	Peak 24-Hour NO_2[(a)(b)]			Peak Annual Average NO_2[(a)(c)]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	31.0	31.3	34.8	3.72	3.93	4.76
Janvier/Chard (IR 194)	24.7	24.8	30.7	3.84	3.99	5.07
Winefred Lake (IR 194B)	11.5	18.4	20.8	2.26	3.83	4.53
Hunter/Trapper A	11.7	13.0	18.3	2.58	3.03	3.87
Hunter/Trapper B	14.9	15.0	21.1	2.24	2.92	3.97
Operator’s Residence	12.0	13.3	18.6	2.72	3.23	4.02
Christina Lake Lodge	13.2	13.2	17.6	2.27	2.50	3.33
La Loche, SK	12.0	12.0	15.6	1.40	1.44	1.99
Maximum Property Boundary	41.8	44.6	44.6	3.77	5.07	6.12

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

(b) The 24-hour Alberta Ambient Air Quality Objective for NO_2 is 200 µg/m³.

(c) The annual Alberta Ambient Air Quality Objective for NO_2 is 60 µg/m³.

Table 10 Existing and Approved Case, Project Case and Planned Development Case Carbon Monoxide (CO) Predictions at Selected Receptors

Receptor	Peak 1-Hour CO[a][b]			Peak 8-Hour CO[a][c]			Peak Annual Average[a][d]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	347.7	347.7	348.5	164.9	165.0	168.6	28.5	28.8	29.6
Janvier/Chard (IR 194)	421.7	421.8	429.4	255.7	255.7	262.0	43.7	43.9	44.9
Winefred Lake (IR 194B)	45.7	80.9	88.6	34.0	43.5	48.6	3.4	5.1	5.8
Hunter/Trapper A	46.9	47.2	46.7	28.4	30.7	36.0	3.8	4.3	5.1
Hunter/Trapper B	55.6	55.6	63.5	43.3	43.3	49.7	3.1	3.9	4.9
Operator’s Residence	55.5	55.6	55.6	30.0	32.7	38.0	3.9	4.5	5.3
Christina Lake Lodge	58.4	58.4	68.0	27.4	27.6	32.6	3.6	3.9	4.7
La Loche, SK	39.5	39.5	43.0	27.3	27.3	31.2	2.1	2.2	2.6
Maximum Property Boundary	433.2	1,153.2	1,156.2	129.9	370.0	370.5	11.6	16.9	17.9

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

(b) The 1-hour Alberta Ambient Air Quality Objective for CO is 15,000 µg/m³.

(c) The 8-hour Alberta Ambient Air Quality Objective for CO is 6,000 µg/m³.

(d) There is no annual Alberta Ambient Air Quality Objective for CO.

1.6.4 Hydrogen Sulphide (H_2S) and Total Reduced Sulphur Predictions

Table 11 summarizes the predicted ground-level H_2S concentrations for the EAC, Project Case and PDC at the selected receptors and the Saskatchewan receptor. The modelling results indicate that the peak 1-hour and 24-hour H_2S concentrations are below the AAAQOs of 14 µg/m³ and 4 µg/m³, respectively, for the three cases.

Total Reduced Sulphur (TRS) emissions are comprised of several compounds in addition to H_2S. Table 12 summarizes the 1-hour, 24-hour and annual ground-level concentrations of various TRS compounds for the EAC, Project Case and PDC at the selected receptors and the Saskatchewan receptor. There are no ambient objectives for TRS compounds, except for H_2S and carbon disulphide (CS_2). The predicted peak 1-hour CS_2 concentrations are below the AAAQO of 30 µg/m³. The health effects resulting from ground-level concentrations of TRS compounds have been assessed in the Human Health Assessment (Section 3).

Table 11 Existing and Approved Case, Project Case and Planned Development Case Hydrogen Sulphide (H_2S) Predictions at Selected Receptors

Receptor	Peak 1-Hour H_2S[a][b]			Peak 24-Hour H_2S [a][c]			Peak Annual Average[a][d]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	0.85	0.85	0.85	0.13	0.13	0.14	0.02	0.02	0.02
Janvier/Chard (IR 194)	0.18	0.18	0.19	0.06	0.06	0.07	0.01	0.01	0.01
Winefred Lake (IR 194B)	0.14	0.39	0.40	0.05	0.15	0.16	0.01	0.01	0.01
Hunter/Trapper A	0.21	0.23	0.23	0.08	0.09	0.09	0.01	0.01	0.01
Hunter/Trapper B	0.21	0.23	0.24	0.05	0.05	0.06	0.01	0.01	0.01
Operator’s Residence	0.42	0.42	0.43	0.14	0.15	0.15	0.01	0.01	0.01
Christina Lake Lodge	0.34	0.34	0.35	0.08	0.08	0.09	0.01	0.01	0.01
La Loche, SK	0.11	0.11	0.12	0.04	0.04	0.04	0.00	0.00	0.00
Maximum Property Boundary	5.97	8.33	8.33	2.49	3.55	3.55	0.26	0.48	0.48

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

(b) The 1-hour Alberta Ambient Air Quality Objective for H_2S is 14 µg/m³.

(c) The 24-hour Alberta Ambient Air Quality Objective for H_2S is 4 µg/m³.

(d) There is no annual Alberta Ambient Air Quality Objective for H_2S.

Table 12 Existing and Approved Case, Project Case and Planned Development Case Total Reduced Sulphur Predictions at Selected Receptors

Averaging Period and Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak 1-Hour [µg/m³][(a)]									
total reduced sulphur (TRS)	1.014700	1.014700	1.031400	1.496300	1.496300	1.740300	0.693180	2.066400	2.103100
hydrogen sulphide (H_2S)[(b)]	0.848660	0.848660	0.851690	0.178930	0.178960	0.188060	0.139890	0.393020	0.399680
carbonyl sulphide (COS)	0.014771	0.014772	0.018764	0.042002	0.042003	0.046876	0.021571	0.021724	0.025841
carbon disulphide (CS_2)[(b)]	0.014544	0.014544	0.018588	0.040248	0.040250	0.044656	0.020895	0.024421	0.025150
mercaptans	0.022166	0.022166	0.022530	0.032252	0.032252	0.037511	0.014942	0.045140	0.045940
thiophenes	0.195520	0.195520	0.226500	0.555610	0.555610	0.676420	0.259520	0.287200	0.312090
Peak 24-Hour [µg/m³][(a)]									
TRS	0.217357	0.225424	0.296110	0.373808	0.374464	0.456544	0.243972	0.685475	0.746227
H_2S[(c)]	0.127203	0.127203	0.136646	0.061426	0.061550	0.069862	0.048667	0.150142	0.160863
COS	0.005857	0.005861	0.007345	0.012212	0.012217	0.014526	0.007859	0.008236	0.009858
CS_2	0.005720	0.005726	0.007394	0.011834	0.011842	0.014068	0.007643	0.008529	0.009917
mercaptans	0.004814	0.004873	0.006505	0.007920	0.007998	0.010045	0.005164	0.014923	0.016245
thiophenes	0.063712	0.063856	0.083623	0.128541	0.129038	0.167666	0.066633	0.097944	0.106943
Peak Annual Average [µg/m³][(a)]									
TRS	0.032667	0.037061	0.048587	0.030239	0.032080	0.046267	0.024147	0.053448	0.062148
H_2S	0.015574	0.016406	0.018271	0.006149	0.006498	0.008680	0.005690	0.011241	0.012552
COS	0.000662	0.000692	0.000871	0.000912	0.000925	0.001171	0.000634	0.000833	0.000998
CS_2	0.000709	0.000757	0.000965	0.000894	0.000914	0.001188	0.000638	0.000961	0.001140
mercaptans	0.000702	0.000798	0.001047	0.000642	0.000682	0.000987	0.000516	0.001156	0.001343
thiophenes	0.006861	0.007471	0.009644	0.008145	0.008401	0.011393	0.005948	0.010021	0.011920

Table 12 Existing and Approved Case, Project Case and Planned Development Case Total Reduced Sulphur Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)									
total reduced sulphur (TRS)	1.079400	1.165500	1.186100	0.971780	0.971780	1.222900	2.223600	2.223600	2.223600
hydrogen sulphide (H_2S)(b)	0.209490	0.225800	0.229360	0.207260	0.234800	0.235530	0.421140	0.423290	0.427510
carbonyl sulphide (COS)	0.020085	0.020102	0.024393	0.030060	0.030062	0.034185	0.020284	0.020284	0.024550
carbon disulphide (CS_2)(b)	0.018833	0.018861	0.022180	0.028996	0.028998	0.032939	0.024479	0.024674	0.025059
mercaptans	0.023555	0.025436	0.025879	0.021124	0.021224	0.026736	0.048574	0.048574	0.048574
thiophenes	0.360360	0.360710	0.426770	0.367220	0.367220	0.438320	0.355620	0.355780	0.421830
Peak 24-Hour [µg/m^3](a)									
TRS	0.426565	0.486510	0.489992	0.282911	0.293158	0.364726	0.732038	0.809996	0.813601
H_2S(c)	0.081510	0.092865	0.093278	0.048957	0.053907	0.061578	0.139215	0.153980	0.154414
COS	0.007385	0.007520	0.009111	0.009397	0.009401	0.011337	0.007580	0.007718	0.009340
CS_2	0.007126	0.007344	0.009006	0.009083	0.009091	0.011061	0.008837	0.009695	0.009846
mercaptans	0.009278	0.010587	0.010659	0.006003	0.006442	0.008026	0.015951	0.017654	0.017728
thiophenes	0.064924	0.068864	0.083448	0.092763	0.095552	0.122896	0.102976	0.113809	0.114835
Peak Annual Average [µg/m^3](a)									
TRS	0.036334	0.044771	0.055090	0.029348	0.041178	0.055241	0.048466	0.058343	0.068667
H_2S	0.009225	0.010823	0.012439	0.007055	0.009296	0.011533	0.011390	0.013261	0.014873
COS	0.000713	0.000770	0.000949	0.000769	0.000849	0.001073	0.000802	0.000869	0.001049
CS_2	0.000769	0.000862	0.001062	0.000775	0.000905	0.001161	0.000908	0.001017	0.001218
mercaptans	0.000782	0.000966	0.001188	0.000626	0.000885	0.001188	0.001047	0.001263	0.001485
thiophenes	0.007634	0.008807	0.010897	0.007271	0.008915	0.011680	0.009365	0.010738	0.012843

Table 12 Existing and Approved Case, Project Case and Planned Development Case Total Reduced Sulphur Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Christina Lake Lodge			La Loche, SK			Maximum Property Boundary		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)									
total reduced sulphur (TRS)	0.663240	0.663240	0.815490	1.065100	1.065100	1.280100	31.530001	43.980999	43.988998
hydrogen sulphide (H_2S)(b)	0.343550	0.343550	0.345660	0.109460	0.109460	0.122800	5.972000	8.330700	8.331200
carbonyl sulphide (COS)	0.016510	0.016510	0.020553	0.019477	0.019482	0.022613	0.214590	0.298980	0.299100
carbon disulphide (CS_2)(b)	0.015407	0.015407	0.018954	0.018947	0.018956	0.021675	0.347360	0.484250	0.484380
mercaptans	0.014298	0.014298	0.017838	0.022959	0.022959	0.027623	0.688740	0.960750	0.960930
thiophenes	0.257900	0.257900	0.292640	0.414860	0.414860	0.526080	4.382700	6.112800	6.117000
Peak 24-Hour [µg/m^3](a)									
TRS	0.195680	0.205258	0.277726	0.280884	0.280889	0.335319	13.125283	18.742447	18.754036
H_2S(c)	0.080078	0.080078	0.089156	0.036607	0.036693	0.038265	2.486032	3.549983	3.552062
COS	0.006141	0.006145	0.007668	0.007429	0.007432	0.009005	0.089633	0.127628	0.127746
CS_2	0.005962	0.005968	0.007669	0.007122	0.007127	0.008494	0.144725	0.206542	0.206703
mercaptans	0.004345	0.004434	0.005900	0.006091	0.006092	0.007266	0.286703	0.409410	0.409661
thiophenes	0.060583	0.060858	0.078609	0.104977	0.104977	0.130870	1.824758	2.605441	2.607139
Peak Annual Average [µg/m^3](a)									
TRS	0.026975	0.031943	0.042740	0.022448	0.022775	0.028647	1.371078	2.523873	2.537952
H_2S	0.010471	0.011412	0.013141	0.003803	0.003865	0.004491	0.261553	0.480956	0.483232
COS	0.000622	0.000656	0.000831	0.000784	0.000787	0.000973	0.009820	0.017669	0.017883
CS_2	0.000646	0.000700	0.000900	0.000749	0.000752	0.000932	0.015492	0.028195	0.028444
mercaptans	0.000578	0.000687	0.000919	0.000477	0.000484	0.000608	0.029938	0.055120	0.055424
thiophenes	0.006085	0.006776	0.008856	0.006284	0.006329	0.008319	0.193359	0.353639	0.356308

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

(b) The 1-hour Alberta Ambient Air Quality Objectives for H_2S and CS_2 are 14 and 30 µg/m^3, respectively.

(c) The 24-hour Alberta Ambient Air Quality Objective for H_2S is 4 µg/m^3.

1.6.5 Volatile Organic Compound and Benzene Predictions

Of the various VOC compounds released from industrial and non-industrial activities in the region, much of the focus has been placed on benzene. Table 13 provides the predicted 1-hour, 24-hour and annual benzene concentrations at the selected receptors and the Saskatchewan receptor for the EAC, Project Case and PDC. The peak benzene concentrations are predicted to be below the 1-hour AAAQO of 30 µg/m³.

A summary of the predicted 1-hour and annual concentrations of selected VOC species are provided in Table 14 and Table 15, respectively, for the EAC, Project Case and PDC at the selected receptors and the Saskatchewan receptor. The predicted peak concentrations of VOC compounds are below the AAAQOs or other criteria, as applicable. For a few compounds at several selected receptors, the VOC predictions decreased slightly (i.e., fourth or fifth decimal place) from the EAC to the Project Case. This is due to rounding errors. In addition, the peak 1-hour benzene concentration at Janvier/Chard (IR 194) decreases from the Project Case to the PDC likely because emissions from the EnCana Christina Lake Thermal Project are expected to decrease in the PDC. The VOC compounds included in the tables were chosen based on species screening performed for the health assessment. The potential effects of these compounds will be assessed separately in the Human Health Assessment (Section 3).

Table 13 Existing and Approved Case, Project Case and Planned Development Case Benzene Predictions at Selected Receptors

Receptor	Peak 1-Hour Benzene[a][b]			Peak 24-Hour Benzene[a][c]			Peak Annual Average Benzene[a][d]		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Conklin	0.6	0.6	0.6	0.2	0.2	0.2	0.0	0.0	0.0
Janvier/Chard (IR 194)	0.4	0.4	0.4	0.1	0.1	0.1	0.0	0.0	0.0
Winefred Lake (IR 194B)	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Hunter/Trapper A	0.3	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0
Hunter/Trapper B	0.3	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0
Operator’s Residence	0.3	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0
Christina Lake Lodge	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
La Loche, SK	1.5	1.5	1.5	1.0	1.0	1.0	0.3	0.3	0.3
Maximum Property Boundary	0.3	0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.0

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

(b) The 1-hour Alberta Ambient Air Quality Objective for benzene is 30 µg/m³.

(c) There is no 24-hour Alberta Ambient Air Quality Objective for benzene.

(d) There is no annual Alberta Ambient Air Quality Objective for benzene.

Table 14 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Volatile Organic Compounds Predictions at Selected Receptors

Averaging Period and Parameter	Conklin			Janvier/Chard (IR 194)		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3][a]						
total VOC	37.931999	37.950001	52.681999	118.570000	118.570000	145.699997
benzene[b]	0.579080	0.579110	0.581390	0.411930	0.411930	0.408690
trimethylbenzene	0.287960	0.287960	0.358440	0.622800	0.622800	0.804300
C_2-C_8 aliphatic	21.834000	21.834000	28.898001	76.158997	76.158997	94.267998
C_9-C_{16} aliphatic	6.693700	6.693700	8.273300	16.503000	16.503000	19.992001
C_{16+} aliphatic	0.384170	0.384170	0.483120	0.933310	0.933300	0.966540
C_6-C_8 aromatic	4.565100	4.565100	5.845200	12.135000	12.135000	14.855000
C_9-C_{16} aromatic	1.137500	1.137500	1.287200	2.271300	2.271300	2.672000
hexane group	4.637600	4.637600	5.867200	17.823000	17.823000	22.164000
aldehyde	1.159100	1.159100	1.167300	1.421200	1.421200	1.798700
ketone	0.395810	0.396270	0.397600	0.498990	0.498980	0.551550
acrolein	0.338960	0.338960	0.339140	0.086463	0.086462	0.108760
1,3-butadiene	0.017802	0.017802	0.017815	0.007747	0.007747	0.009774
formaldehyde[b]	3.483600	3.483700	3.504900	0.626500	0.626510	0.791990
1,1,1-trichloroethane	0.000128	0.000128	0.000128	0.000017	0.000017	0.000017
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde[b]	0.843290	0.843290	0.849190	1.026100	1.026100	1.298700
acetone[b]	0.428360	0.428360	0.431460	0.536420	0.536420	0.679010
cumene[b]	0.402190	0.402190	0.545630	1.065000	1.065100	1.338700
ethylbenzene[b]	1.347900	1.347900	1.492100	2.471700	2.471700	2.793200
ethylene[b]	2.241800	2.241800	2.243100	0.255230	0.255230	0.311240
2-ethylhexanol[b]	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene[b]	1.958900	1.958900	2.438900	4.288700	4.288700	5.479900
xylenes[b]	2.110400	2.110400	2.628000	5.599900	5.599900	6.746500
1,1,2-trichloroethanes	0.002066	0.002066	0.002066	0.000210	0.000210	0.000210
1,2-dichloropropane	0.001748	0.001748	0.001748	0.000178	0.000178	0.000178
1,3-dichloropropene	0.001715	0.001715	0.001715	0.000174	0.000174	0.000174
carbon tetrachloride	0.002384	0.002384	0.002384	0.000242	0.000242	0.000242
chlorobenzene	0.001975	0.001975	0.001975	0.000201	0.000201	0.000201
chloroethane	0.000121	0.000121	0.000121	0.000012	0.000012	0.000012
chloroform	0.001852	0.001852	0.001852	0.000188	0.000188	0.000188
dichloroethanes	0.003066	0.003066	0.003066	0.000312	0.000312	0.000312
methanol[b]	0.162410	0.162410	0.162410	0.016513	0.016513	0.016513
methylene chloride	0.001299	0.001299	0.001299	0.000132	0.000132	0.000132
phenol[b]	0.001559	0.001559	0.001559	0.000159	0.000159	0.000159
tetrachloroethanes	0.002760	0.002760	0.002760	0.000281	0.000281	0.000281
vinyl chloride[b]	0.000968	0.000968	0.000968	0.000098	0.000098	0.000098
styrene[b]	0.001533	0.001533	0.001533	0.000156	0.000156	0.000156
isopropanol[b]	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide[b]	0.001147	0.001147	0.001502	0.001597	0.001597	0.002453

Table 14 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Winefred Lake (IR 194B)			Hunter/Trapper A		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)						
total VOC	60.320000	60.325001	73.246002	74.575996	74.611000	91.787003
benzene(b)	0.196200	0.196200	0.204330	0.264080	0.264090	0.266550
trimethylbenzene	0.334320	0.334320	0.410940	0.456950	0.456950	0.566910
C_2-C_8 aliphatic	36.299999	36.305000	44.316002	47.820000	47.872002	58.680000
C_9-C_{16} aliphatic	8.551700	8.557500	11.250000	11.194000	11.195000	13.579001
C_{16+} aliphatic	0.541720	0.541720	0.551670	0.437460	0.437460	0.458450
C_6-C_8 aromatic	6.256400	6.256400	7.524400	6.973200	6.973200	8.620700
C_9-C_{16} aromatic	1.306700	1.306700	1.531000	1.180400	1.180400	1.413200
hexane group	8.058300	8.059000	9.857400	10.853000	10.860000	13.337000
aldehyde	0.693340	0.693340	0.918060	0.647410	0.647410	0.839620
ketone	0.266530	0.266530	0.294400	0.225200	0.225230	0.259250
acrolein	0.041927	0.041926	0.055209	0.039168	0.039168	0.051706
1,3-butadiene	0.003768	0.003768	0.004975	0.003519	0.003519	0.004608
formaldehyde(b)	0.312890	0.316400	0.421060	0.327990	0.328270	0.395010
1,1,1-trichloroethane	0.000028	0.000028	0.000028	0.000022	0.000022	0.000022
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde(b)	0.500580	0.500580	0.662830	0.467260	0.467260	0.606830
acetone(b)	0.261740	0.261740	0.346570	0.244600	0.244600	0.316070
cumene(b)	0.595830	0.595830	0.744040	0.668140	0.668140	0.828670
ethylbenzene(b)	1.468500	1.468500	1.663700	1.320800	1.320800	1.495900
ethylene(b)	0.122380	0.122410	0.159030	0.115080	0.115090	0.143390
2-ethylhexanol(b)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene(b)	2.335000	2.335100	2.861000	3.116900	3.116900	3.855500
xylenes(b)	2.799900	2.799900	3.381100	2.974500	2.974500	3.678500
1,1,2-trichloroethanes	0.000132	0.000132	0.000132	0.000177	0.000177	0.000177
1,2-dichloropropane	0.000112	0.000112	0.000112	0.000150	0.000150	0.000150
1,3-dichloropropene	0.000110	0.000110	0.000110	0.000147	0.000147	0.000147
carbon tetrachloride	0.000153	0.000153	0.000153	0.000205	0.000205	0.000205
chlorobenzene	0.000126	0.000126	0.000126	0.000170	0.000170	0.000170
chloroethane	0.000008	0.000008	0.000008	0.000010	0.000010	0.000010
chloroform	0.000119	0.000119	0.000119	0.000159	0.000159	0.000159
dichloroethanes	0.000196	0.000196	0.000196	0.000263	0.000263	0.000263
methanol(b)	0.010402	0.010402	0.010402	0.013950	0.013950	0.013950
methylene chloride	0.000083	0.000083	0.000083	0.000112	0.000112	0.000112
phenol(b)	0.000100	0.000100	0.000100	0.000134	0.000134	0.000134
tetrachloroethanes	0.000177	0.000177	0.000177	0.000237	0.000237	0.000237
vinyl chloride(b)	0.000062	0.000062	0.000062	0.000083	0.000083	0.000083
styrene(b)	0.000098	0.000098	0.000098	0.000132	0.000132	0.000132
isopropanol(b)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide(b)	0.002176	0.002176	0.002203	0.005201	0.005201	0.005214

Table 14 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Hunter/Trapper B			Operator's Residence		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)						
total VOC	81.522003	81.560997	104.339996	74.691002	74.695000	91.599999
benzene(b)	0.272570	0.272580	0.307210	0.262450	0.262450	0.263700
trimethylbenzene	0.457470	0.457470	0.585700	0.449750	0.449750	0.557100
C_2-C_8 aliphatic	49.727001	49.727001	63.327999	47.710999	47.717999	58.375000
C_9-C_{16} aliphatic	11.746000	11.746000	14.883000	11.065000	11.066000	13.358000
C_{16+} aliphatic	0.666840	0.666830	0.741300	0.453360	0.453360	0.485680
C_6-C_8 aromatic	8.898300	8.898400	11.006000	7.031500	7.031500	8.665800
C_9-C_{16} aromatic	1.739700	1.739700	2.061400	1.216900	1.216900	1.452400
hexane group	11.223000	11.223000	14.260000	10.834000	10.835000	13.289000
aldehyde	0.986540	0.986540	1.292400	0.658570	0.658570	0.868260
ketone	0.353400	0.353390	0.413670	0.229090	0.229090	0.271790
acrolein	0.059498	0.059498	0.077576	0.039611	0.039611	0.052461
1,3-butadiene	0.005353	0.005353	0.006996	0.003568	0.003568	0.004709
formaldehyde(b)	0.426300	0.426330	0.570280	0.352890	0.353200	0.400110
1,1,1-trichloroethane	0.000021	0.000021	0.000021	0.000023	0.000023	0.000023
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde(b)	0.712080	0.712070	0.932940	0.475210	0.475210	0.626870
acetone(b)	0.372690	0.372680	0.488170	0.248980	0.248980	0.327790
cumene(b)	0.762030	0.762030	0.970250	0.670260	0.670260	0.828140
ethylbenzene(b)	1.913100	1.913100	2.160500	1.363600	1.363600	1.541700
ethylene(b)	0.176070	0.176070	0.223840	0.117260	0.117260	0.149240
2-ethylhexanol(b)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene(b)	3.159800	3.159800	4.008200	3.073800	3.073800	3.794200
xylenes(b)	4.119700	4.119700	4.991800	3.024000	3.024000	3.727100
1,1,2-trichloroethanes	0.000198	0.000198	0.000198	0.000192	0.000192	0.000192
1,2-dichloropropane	0.000167	0.000167	0.000167	0.000163	0.000163	0.000163
1,3-dichloropropene	0.000164	0.000164	0.000164	0.000160	0.000160	0.000160
carbon tetrachloride	0.000228	0.000228	0.000228	0.000222	0.000222	0.000222
chlorobenzene	0.000189	0.000189	0.000189	0.000184	0.000184	0.000184
chloroethane	0.000012	0.000012	0.000012	0.000011	0.000011	0.000011
chloroform	0.000177	0.000177	0.000177	0.000172	0.000172	0.000172
dichloroethanes	0.000294	0.000294	0.000294	0.000285	0.000285	0.000285
methanol(b)	0.015554	0.015554	0.015554	0.015116	0.015116	0.015116
methylene chloride	0.000124	0.000124	0.000124	0.000121	0.000121	0.000121
phenol(b)	0.000149	0.000149	0.000149	0.000145	0.000145	0.000145
tetrachloroethanes	0.000264	0.000264	0.000264	0.000257	0.000257	0.000257
vinyl chloride(b)	0.000093	0.000093	0.000093	0.000090	0.000090	0.000090
styrene(b)	0.000147	0.000147	0.000147	0.000143	0.000143	0.000143
isopropanol(b)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide(b)	0.002566	0.002566	0.002600	0.012848	0.012848	0.012848

Table 14 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Christina Lake Lodge			La Loche, SK		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)						
total VOC	48.300999	48.300999	61.571999	86.844002	86.844002	96.595001
benzene(b)	0.170360	0.170360	0.191720	1.524700	1.524700	1.525400
trimethylbenzene	0.361050	0.361050	0.452030	0.366770	0.366770	0.430500
C_2-C_8 aliphatic	30.139000	30.139000	38.330002	58.445999	58.445999	69.571999
C_9-C_{16} aliphatic	8.526600	8.526600	10.839000	9.676300	9.676300	10.583000
C_{16+} aliphatic	0.693610	0.693610	0.789060	0.946520	0.946530	0.961370
C_6-C_8 aromatic	4.768800	4.768800	6.017000	6.752600	6.752600	6.965500
C_9-C_{16} aromatic	1.027800	1.027800	1.193200	1.783600	1.783600	1.842400
hexane group	6.420500	6.420500	8.084400	14.993000	14.993000	18.065001
aldehyde	0.495700	0.495700	0.663770	3.046300	3.046300	3.048700
ketone	0.272290	0.272290	0.314330	1.025000	1.025000	1.025400
acrolein	0.089542	0.089542	0.090926	0.178580	0.178580	0.178720
1,3-butadiene	0.004804	0.004804	0.004929	0.016282	0.016282	0.016295
formaldehyde(b)	0.909690	0.909730	0.922260	1.178000	1.178000	1.179000
1,1,1-trichloroethane	0.000021	0.000021	0.000021	0.000025	0.000025	0.000025
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde(b)	0.357890	0.357890	0.479080	2.195400	2.195500	2.197200
acetone(b)	0.187110	0.187110	0.250780	1.155500	1.155500	1.156400
cumene(b)	0.506020	0.506020	0.641700	0.421910	0.421910	0.519300
ethylbenzene(b)	1.225500	1.225500	1.364100	2.340700	2.340700	2.380800
ethylene(b)	0.111600	0.111610	0.131990	5.899900	5.899900	5.900300
2-ethylhexanol(b)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene(b)	2.453500	2.453500	3.081000	2.451300	2.451300	2.832000
xylenes(b)	2.113800	2.113800	2.615700	3.139000	3.139000	3.229500
1,1,2-trichloroethanes	0.000530	0.000530	0.000530	0.000024	0.000024	0.000024
1,2-dichloropropane	0.000448	0.000448	0.000448	0.000020	0.000020	0.000020
1,3-dichloropropene	0.000440	0.000440	0.000440	0.000020	0.000020	0.000020
carbon tetrachloride	0.000612	0.000612	0.000612	0.000027	0.000027	0.000027
chlorobenzene	0.000507	0.000507	0.000507	0.000023	0.000023	0.000023
chloroethane	0.000031	0.000031	0.000031	0.000001	0.000001	0.000001
chloroform	0.000475	0.000475	0.000475	0.000021	0.000021	0.000021
dichloroethanes	0.000786	0.000786	0.000786	0.000035	0.000035	0.000035
methanol(b)	0.041656	0.041656	0.041656	0.001865	0.001865	0.001865
methylene chloride	0.000333	0.000333	0.000333	0.000015	0.000015	0.000015
phenol(b)	0.000400	0.000400	0.000400	0.000018	0.000018	0.000018
tetrachloroethanes	0.000708	0.000708	0.000708	0.000032	0.000032	0.000032
vinyl chloride(b)	0.000248	0.000248	0.000248	0.000011	0.000011	0.000011
styrene(b)	0.000393	0.000393	0.000393	0.000018	0.000018	0.000018
isopropanol(b)	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide(b)	0.000966	0.000966	0.001476	0.000616	0.000616	0.001152

Table 14 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Maximum Property Boundary		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)			
total VOC	75.929001	79.388001	92.011002
benzene(b)	0.252110	0.252110	0.261880
trimethylbenzene	0.441250	0.441260	0.550240
C_2-C_8 aliphatic	49.980000	118.849998	119.330002
C_9-C_{16} aliphatic	11.060000	13.811000	15.537000
C_{16+} aliphatic	1.165000	1.633900	1.683600
C_6-C_8 aromatic	7.050600	7.050600	8.658400
C_9-C_{16} aromatic	1.898000	1.898200	1.901200
hexane group	10.885000	16.695000	16.766001
aldehyde	0.760710	0.760710	1.012500
ketone	0.444920	0.647840	0.663090
acrolein	0.171360	0.171360	0.171720
1,3-butadiene	0.008939	0.008939	0.008973
formaldehyde(b)	2.124200	2.126500	2.126500
1,1,1-trichloroethane	0.000028	0.000028	0.000028
OCDD	0.000000	0.000000	0.000000
acetaldehyde(b)	0.549310	0.549310	0.731120
acetone(b)	0.287160	0.287160	0.382130
cumene(b)	0.671680	0.671680	0.828100
ethylbenzene(b)	2.554100	2.554100	2.555300
ethylene(b)	0.135690	0.150420	0.192160
2-ethylhexanol(b)	0.000000	0.000000	0.000000
toluene(b)	3.005000	3.021500	3.745600
xylenes(b)	3.367200	3.368700	3.840600
1,1,2-trichloroethanes	0.001054	0.001054	0.001054
1,2-dichloropropane	0.000892	0.000892	0.000892
1,3-dichloropropene	0.000875	0.000875	0.000875
carbon tetrachloride	0.001216	0.001216	0.001216
chlorobenzene	0.001008	0.001008	0.001008
chloroethane	0.000062	0.000062	0.000062
chloroform	0.000945	0.000945	0.000945
dichloroethanes	0.001565	0.001565	0.001565
methanol(b)	0.082866	0.082866	0.082866
methylene chloride	0.000663	0.000663	0.000663
phenol(b)	0.000796	0.000796	0.000796
tetrachloroethanes	0.001408	0.001408	0.001408
vinyl chloride(b)	0.000494	0.000494	0.000494
styrene(b)	0.000782	0.000782	0.000782
isopropanol(b)	0.000000	0.000000	0.000000
propylene oxide(b)	0.081733	0.081733	0.081733

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

(b) The following compounds have 1-hour Alberta AAAQOs: benzene is 30 µg/m^3, formaldehyde is 65 µg/m^3, acetaldehyde is 90 µg/m^3, acetone is 5,900 µg/m^3, cumene is 500 µg/m^3, ethylbenzene is 2,000 µg/m^3, ethylene is 1,200 µg/m^3, 2-ethylhexanol is 600 µg/m^3, toluene is 1,880 µg/m^3, xylenes is 2,300 µg/m^3, methanol is 2,600 µg/m^3, phenol is 100 µg/m^3, vinyl chloride is 130 µg/m^3, styrene is 215 µg/m^3, isopropanol is 7,850 µg/m^3 and propylene oxide is 480 µg/m^3.

Table 15 Existing and Approved Case, Project Case and Planned Development Case Annual Volatile Organic Compounds Predictions at Selected Receptors

Averaging Period and Parameter	Conklin			Janvier/Chard (IR 194)		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak Annual Average [µg/m^3][a]						
total VOC	2.797605	2.816284	3.452529	2.315096	2.328665	3.241389
benzene	0.032920	0.032928	0.035995	0.012334	0.012340	0.015995
trimethylbenzene	0.006897	0.006897	0.010138	0.009776	0.009776	0.014876
C_2-C_8 aliphatic	1.045749	1.071937	1.424965	1.188246	1.208140	1.721020
C_9-C_{16} aliphatic	0.301748	0.302893	0.461062	0.361364	0.361845	0.572418
C_{16+} aliphatic	0.026969	0.027125	0.039647	0.022762	0.022828	0.037425
C_6-C_8 aromatic	0.153855	0.153909	0.204416	0.207663	0.207689	0.285038
C_9-C_{16} aromatic	0.032136	0.032136	0.040593	0.044682	0.044682	0.057566
hexane group	0.124958	0.128590	0.185584	0.210808	0.213593	0.301848
aldehyde	0.072763	0.072763	0.079190	0.039082	0.039082	0.048970
ketone	0.023468	0.023526	0.028871	0.013466	0.013491	0.019976
acrolein	0.007036	0.007036	0.007417	0.003439	0.003439	0.004025
1,3-butadiene	0.000521	0.000521	0.000556	0.000264	0.000264	0.000317
formaldehyde	0.059899	0.060050	0.063744	0.029523	0.029639	0.035130
1,1,1-trichloroethane	0.000006	0.000006	0.000006	0.000001	0.000001	0.000001
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde	0.053802	0.053802	0.058446	0.028743	0.028743	0.035888
acetone	0.025668	0.025668	0.028089	0.014007	0.014007	0.017732
cumene	0.014305	0.014305	0.019827	0.022804	0.022805	0.031277
ethylbenzene	0.026210	0.026210	0.032460	0.040830	0.040830	0.050342
ethylene[b]	0.106981	0.106989	0.108543	0.022616	0.022619	0.024775
2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene	0.067230	0.067278	0.092666	0.076600	0.076622	0.115099
xylenes	0.063320	0.063324	0.082462	0.091814	0.091815	0.121591
1,1,2-trichloroethanes	0.000019	0.000019	0.000019	0.000008	0.000008	0.000008
1,2-dichloropropane	0.000016	0.000016	0.000016	0.000007	0.000007	0.000007
1,3-dichloropropene	0.000016	0.000016	0.000016	0.000006	0.000006	0.000006
carbon tetrachloride	0.000022	0.000022	0.000022	0.000009	0.000009	0.000009
chlorobenzene	0.000018	0.000018	0.000018	0.000007	0.000007	0.000007
chloroethane	0.000001	0.000001	0.000001	0.000000	0.000000	0.000000
chloroform	0.000017	0.000017	0.000017	0.000007	0.000007	0.000007
dichloroethanes	0.000028	0.000028	0.000028	0.000012	0.000012	0.000012
methanol	0.001488	0.001488	0.001488	0.000614	0.000614	0.000614
methylene chloride	0.000012	0.000012	0.000012	0.000005	0.000005	0.000005
phenol	0.000014	0.000014	0.000014	0.000006	0.000006	0.000006
tetrachloroethanes	0.000025	0.000025	0.000025	0.000010	0.000010	0.000010
vinyl chloride	0.000009	0.000009	0.000009	0.000004	0.000004	0.000004
styrene	0.000014	0.000014	0.000014	0.000006	0.000006	0.000006
isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide[b]	0.000040	0.000040	0.000072	0.000056	0.000056	0.000105

Table 15 Existing and Approved Case, Project Case and Planned Development Case Annual Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Winefred Lake (IR 194B)			Hunter/Trapper A		
	EAC [μg/m^3]	Project Case [μg/m^3]	PDC [μg/m^3]	EAC [μg/m^3]	Project Case [μg/m^3]	PDC [μg/m^3]
Peak Annual Average [μg/m^3][a]						
total VOC	1.407253	1.535346	2.158503	1.427586	1.466367	2.124534
benzene	0.005519	0.005573	0.007886	0.005795	0.005811	0.008567
trimethylbenzene	0.006492	0.006493	0.010182	0.006501	0.006501	0.010131
C_2-C_8 aliphatic	0.799562	0.979661	1.336897	0.830388	0.885192	1.261786
C_9-C_{16} aliphatic	0.225151	0.232791	0.370427	0.227997	0.230197	0.382417
C_{16+} aliphatic	0.012560	0.013601	0.022093	0.012856	0.013156	0.023790
C_6-C_8 aromatic	0.138210	0.138574	0.193690	0.137805	0.137910	0.193029
C_9-C_{16} aromatic	0.030167	0.030170	0.039423	0.030089	0.030090	0.039342
hexane group	0.144294	0.169286	0.231196	0.145776	0.153390	0.216461
aldehyde	0.021350	0.021350	0.028070	0.021588	0.021588	0.028523
ketone	0.006832	0.007220	0.011096	0.006926	0.007038	0.011734
acrolein	0.002025	0.002025	0.002424	0.002312	0.002312	0.002723
1,3-butadiene	0.000151	0.000151	0.000187	0.000165	0.000165	0.000203
formaldehyde	0.019256	0.020296	0.024045	0.022078	0.022395	0.026367
1,1,1-trichloroethane	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde	0.015790	0.015790	0.020646	0.016090	0.016090	0.021101
acetone	0.007528	0.007528	0.010060	0.007436	0.007436	0.010048
cumene	0.015436	0.015436	0.021557	0.015453	0.015453	0.021552
ethylbenzene	0.028203	0.028203	0.035024	0.028037	0.028037	0.034838
ethylene[b]	0.004025	0.004077	0.005470	0.004141	0.004156	0.005688
2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene	0.049246	0.049568	0.076897	0.049386	0.049479	0.076996
xylenes	0.061602	0.061628	0.082878	0.061209	0.061217	0.082307
1,1,2-trichloroethanes	0.000005	0.000005	0.000005	0.000007	0.000007	0.000007
1,2-dichloropropane	0.000004	0.000004	0.000004	0.000006	0.000006	0.000006
1,3-dichloropropene	0.000004	0.000004	0.000004	0.000006	0.000006	0.000006
carbon tetrachloride	0.000006	0.000006	0.000006	0.000008	0.000008	0.000008
chlorobenzene	0.000005	0.000005	0.000005	0.000007	0.000007	0.000007
chloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
chloroform	0.000005	0.000005	0.000005	0.000006	0.000006	0.000006
dichloroethanes	0.000008	0.000008	0.000008	0.000011	0.000011	0.000011
methanol	0.000410	0.000410	0.000410	0.000558	0.000558	0.000558
methylene chloride	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004
phenol	0.000004	0.000004	0.000004	0.000005	0.000005	0.000005
tetrachloroethanes	0.000007	0.000007	0.000007	0.000009	0.000009	0.000009
vinyl chloride	0.000002	0.000002	0.000002	0.000003	0.000003	0.000003
styrene	0.000004	0.000004	0.000004	0.000005	0.000005	0.000005
isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide[b]	0.000084	0.000084	0.000117	0.000069	0.000069	0.000104

Table 15 Existing and Approved Case, Project Case and Planned Development Case Annual Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Hunter/Trapper B			Operator's Residence		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak Annual Average [µg/m^3]$^{(a)}$						
total VOC	1.688965	1.743505	2.560427	1.463688	1.506969	2.170042
benzene	0.006767	0.006790	0.010526	0.005861	0.005879	0.008635
trimethylbenzene	0.007911	0.007911	0.012202	0.006605	0.006605	0.010291
C_2-C_8 aliphatic	0.938602	1.015705	1.474244	0.855211	0.916080	1.294104
C_9-C_{16} aliphatic	0.277789	0.280873	0.478699	0.234925	0.237500	0.390608
C_{16+} aliphatic	0.015702	0.016123	0.031171	0.013519	0.013870	0.024470
C_6-C_8 aromatic	0.166727	0.166876	0.232732	0.140145	0.140268	0.196157
C_9-C_{16} aromatic	0.036227	0.036228	0.047128	0.030507	0.030508	0.039883
hexane group	0.170074	0.180786	0.256718	0.149937	0.158384	0.221969
aldehyde	0.025684	0.025684	0.033996	0.021840	0.021840	0.028858
ketone	0.008408	0.008565	0.015051	0.007199	0.007330	0.012023
acrolein	0.002635	0.002635	0.003128	0.002309	0.002309	0.002726
1,3-butadiene	0.000191	0.000191	0.000236	0.000166	0.000166	0.000204
formaldehyde	0.024029	0.024475	0.029246	0.022493	0.022845	0.026850
1,1,1-trichloroethane	0.000000	0.000000	0.000000	0.000001	0.000001	0.000001
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde	0.019079	0.019079	0.025086	0.016269	0.016269	0.021341
acetone	0.008937	0.008937	0.012068	0.007535	0.007535	0.010179
cumene	0.018727	0.018727	0.025909	0.015675	0.015675	0.021859
ethylbenzene	0.033639	0.033639	0.041645	0.028443	0.028443	0.035335
ethylene$^{(b)}$	0.004845	0.004867	0.006818	0.004190	0.004208	0.005749
2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene	0.059890	0.060020	0.093173	0.050356	0.050464	0.078356
xylenes	0.074200	0.074211	0.099257	0.062184	0.062193	0.083592
1,1,2-trichloroethanes	0.000008	0.000008	0.000008	0.000007	0.000007	0.000007
1,2-dichloropropane	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
1,3-dichloropropene	0.000006	0.000006	0.000006	0.000006	0.000006	0.000006
carbon tetrachloride	0.000009	0.000009	0.000009	0.000008	0.000008	0.000008
chlorobenzene	0.000007	0.000007	0.000007	0.000007	0.000007	0.000007
chloroethane	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
chloroform	0.000007	0.000007	0.000007	0.000006	0.000006	0.000006
dichloroethanes	0.000011	0.000011	0.000011	0.000010	0.000010	0.000010
methanol	0.000603	0.000603	0.000603	0.000547	0.000547	0.000547
methylene chloride	0.000005	0.000005	0.000005	0.000004	0.000004	0.000004
phenol	0.000006	0.000006	0.000006	0.000005	0.000005	0.000005
tetrachloroethanes	0.000010	0.000010	0.000010	0.000009	0.000009	0.000009
vinyl chloride	0.000004	0.000004	0.000004	0.000003	0.000003	0.000003
styrene	0.000006	0.000006	0.000006	0.000005	0.000005	0.000005
isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide$^{(b)}$	0.000059	0.000059	0.000101	0.000088	0.000088	0.000124

Table 15 Existing and Approved Case, Project Case and Planned Development Case Annual Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Christina Lake Lodge			La Loche, SK		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak Annual Average [µg/m^3](a)						
total VOC	1.309142	1.329826	1.958312	16.697430	16.701094	17.497786
benzene	0.006405	0.006414	0.009296	0.270513	0.270515	0.272412
trimethylbenzene	0.005956	0.005956	0.009243	0.018297	0.018297	0.024477
C_2-C_8 aliphatic	0.730449	0.759378	1.113445	3.908842	3.914322	4.364952
C_9-C_{16} aliphatic	0.208896	0.210191	0.362137	1.272671	1.272756	1.426818
C_{16+} aliphatic	0.011795	0.011971	0.023515	0.177959	0.177970	0.181698
C_6-C_8 aromatic	0.127118	0.127179	0.177973	0.462622	0.462627	0.546798
C_9-C_{16} aromatic	0.028051	0.028052	0.036588	0.088011	0.088011	0.101749
hexane group	0.123859	0.127869	0.185648	0.202465	0.203236	0.289320
aldehyde	0.022304	0.022304	0.028759	0.552525	0.552525	0.562107
ketone	0.006555	0.006620	0.011605	0.185990	0.185995	0.188401
acrolein	0.003071	0.003071	0.003454	0.032570	0.032570	0.033138
1,3-butadiene	0.000203	0.000203	0.000238	0.002962	0.002962	0.003013
formaldehyde	0.028966	0.029133	0.032840	0.217165	0.217197	0.221916
1,1,1-trichloroethane	0.000001	0.000001	0.000001	0.000005	0.000005	0.000005
OCDD	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
acetaldehyde	0.016947	0.016947	0.021611	0.398302	0.398302	0.405223
acetone	0.007224	0.007224	0.009656	0.209434	0.209434	0.213048
cumene	0.014356	0.014356	0.019942	0.020097	0.020097	0.029792
ethylbenzene	0.026042	0.026042	0.032344	0.045090	0.045090	0.054538
ethylene(b)	0.005304	0.005313	0.006821	1.028462	1.028463	1.030028
2-ethylhexanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
toluene	0.045396	0.045450	0.070890	0.283595	0.283600	0.326402
xylenes	0.056486	0.056490	0.075812	0.157812	0.157813	0.190144
1,1,2-trichloroethanes	0.000012	0.000012	0.000012	0.000001	0.000001	0.000001
1,2-dichloropropane	0.000010	0.000010	0.000010	0.000001	0.000001	0.000001
1,3-dichloropropene	0.000010	0.000010	0.000010	0.000001	0.000001	0.000001
carbon tetrachloride	0.000014	0.000014	0.000014	0.000001	0.000001	0.000001
chlorobenzene	0.000012	0.000012	0.000012	0.000001	0.000001	0.000001
chloroethane	0.000001	0.000001	0.000001	0.000000	0.000000	0.000000
chloroform	0.000011	0.000011	0.000011	0.000001	0.000001	0.000001
dichloroethanes	0.000018	0.000018	0.000018	0.000002	0.000002	0.000002
methanol	0.000946	0.000946	0.000946	0.000094	0.000094	0.000094
methylene chloride	0.000008	0.000008	0.000008	0.000001	0.000001	0.000001
phenol	0.000009	0.000009	0.000009	0.000001	0.000001	0.000001
tetrachloroethanes	0.000016	0.000016	0.000016	0.000002	0.000002	0.000002
vinyl chloride	0.000006	0.000006	0.000006	0.000001	0.000001	0.000001
styrene	0.000009	0.000009	0.000009	0.000001	0.000001	0.000001
isopropanol	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
propylene oxide(b)	0.000041	0.000041	0.000072	0.000046	0.000046	0.000085

Table 15 Existing and Approved Case, Project Case and Planned Development Case Annual Volatile Organic Compounds Predictions at Selected Receptors (continued)

Averaging Period and Parameter	Maximum Property Boundary		
	EAC [μg/m^3]	Project Case [μg/m^3]	PDC [μg/m^3]
Peak Annual Average [μg/m^3]$^{(a)}$			
total VOC	2.677335	3.632965	4.402137
benzene	0.006906	0.007805	0.011572
trimethylbenzene	0.007166	0.007183	0.011076
C_2-C_8 aliphatic	1.825023	2.622239	3.053369
C_9-C_{16} aliphatic	0.594060	0.899356	1.091641
C_{16+} aliphatic	0.061404	0.102589	0.117952
C_6-C_8 aromatic	0.164516	0.177047	0.237559
C_9-C_{16} aromatic	0.033149	0.033296	0.043297
hexane group	0.270195	0.358152	0.427947
aldehyde	0.025530	0.025530	0.033151
ketone	0.025150	0.040550	0.047078
acrolein	0.003673	0.003673	0.004125
1,3-butadiene	0.000240	0.000240	0.000281
formaldehyde	0.042793	0.043232	0.047393
1,1,1-trichloroethane	0.000001	0.000001	0.000001
OCDD	0.000000	0.000000	0.000000
acetaldehyde	0.019477	0.019477	0.024984
acetone	0.008156	0.008156	0.011026
cumene	0.017055	0.017055	0.023616
ethylbenzene	0.030858	0.030859	0.038220
ethylene$^{(b)}$	0.006743	0.009022	0.010889
2-ethylhexanol	0.000000	0.000000	0.000000
toluene	0.067142	0.077775	0.108372
xylenes	0.067881	0.069461	0.092323
1,1,2-trichloroethanes	0.000015	0.000015	0.000015
1,2-dichloropropane	0.000013	0.000013	0.000013
1,3-dichloropropene	0.000012	0.000012	0.000012
carbon tetrachloride	0.000017	0.000017	0.000017
chlorobenzene	0.000014	0.000014	0.000014
chloroethane	0.000001	0.000001	0.000001
chloroform	0.000013	0.000013	0.000013
dichloroethanes	0.000022	0.000022	0.000022
methanol	0.001167	0.001167	0.001167
methylene chloride	0.000009	0.000009	0.000009
phenol	0.000011	0.000011	0.000011
tetrachloroethanes	0.000020	0.000020	0.000020
vinyl chloride	0.000007	0.000007	0.000007
styrene	0.000011	0.000011	0.000011
isopropanol	0.000000	0.000000	0.000000
propylene oxide$^{(b)}$	0.000738	0.000738	0.000775

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

(b) There are no annual AAAQOs for VOC compounds except for ethylene (30 μg/m^3) and propylene oxide (30 μg/m^3).

1.6.6 Fine Particulate Predictions

Ambient concentrations of $PM_{2.5}$ at the selected receptors and the Saskatchewan receptor were estimated for two categories of particulate matter: (1) primary particulate matter and (2) secondary aerosols. The second category of fine particulates results from gaseous emissions of sulphur dioxide (SO_2) and oxides of nitrogen (NO_X) undergoing chemical transformations in the atmosphere. In calculating secondary aerosol concentrations, airborne nitrate and sulphate concentrations predicted by CALPUFF were combined with ammonia and then summed. This estimate of secondary aerosols does not account for all of the complex chemistry involved in the formation of aerosols in the atmosphere. However, more sophisticated techniques have not made the transition from academic research models to practical models available for use in EIAs.

Predicted ground-level $PM_{2.5}$ concentrations at the selected receptors and the Saskatchewan receptor are presented in Table 16 for the EAC, the Project Case and the PDC. Monitored data were used to represent background ground-level concentrations of $PM_{2.5}$ within the communities resulting from community sources (discussed in Appendix 3-II, Section 2.3.9). The modelling results indicate the following:

- Peak 1-hour and 24-hour $PM_{2.5}$ concentrations at the selected receptors and the Saskatchewan receptor are below the AAAQOs of 80 $\mu g/m^3$ and 30 $\mu g/m^3$, respectively, with one exception. In the Project Case and the PDC, the predicted peak 1-hour concentration at the Maximum Property Boundary exceeded the AAAQO of 80 $\mu g/m^3$.
- The 98th percentile $PM_{2.5}$ concentrations are below the Canada-Wide Standard of 30 $\mu g/m^3$. The Clean Air Strategic Alliance (CASA) has established action triggers, in addition to the Canada-Wide Standard, for the management of $PM_{2.5}$ (CASA 2003). These action triggers define the action levels in the management framework. Although the framework was developed based on monitored air concentrations, the predicted 98th percentile concentrations were provided for comparison purposes. As such, the 98th percentile $PM_{2.5}$ concentrations are below the “surveillance” trigger value of 15 $\mu g/m^3$ (24-hour), which is considered “baseline”. At the baseline action level, activities are limited to collecting ambient data.

Table 16 Existing and Approved Case, Project Case and Planned Development Case Particulate Matter (2.5 microns or less) Predictions at Selected Receptors

Receptor	Peak 1-Hour [µg/m^3](a)(b)			Peak 24-Hour [µg/m^3](a)(b)			98th Percentile 24-Hour [µg/m^3](c)		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Conklin	24.5	24.6	30.2	16.9	17.1	21.0	9.4	9.6	10.8
Janvier/Chard (IR 194)	54.2	54.2	64.2	21.8	22.0	26.8	9.8	10.1	11.1
Winefred Lake (IR 194B)	34.3	34.4	44.4	13.8	14.5	18.8	3.6	4.2	5.1
Hunter/Trapper A	26.9	27.3	35.4	13.1	13.6	17.9	3.6	3.9	5.1
Hunter/Trapper B	37.0	37.0	47.2	14.6	14.9	19.6	3.9	4.4	5.7
Operator’s Residence	28.3	29.1	37.8	13.3	13.8	18.2	3.9	4.1	5.1
Christina Lake Lodge	18.5	18.5	24.3	11.5	11.7	15.8	3.4	3.7	4.8
La Loche, SK	16.3	16.3	20.5	5.0	5.0	6.4	2.5	2.5	3.1
Maximum Property Boundary	45.6	101.2(d)	101.4(d)	16.2	19.5	24.0	5.9	9.9	10.9

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

(b) The 1-hour and 24-hour Alberta Ambient Air Quality Objectives for PM$_{2.5}$ is 80 µg/m^3 and 30 µg/m^3, respectively.

(c) The Canada-Wide Standard for PM$_{2.5}$ is achieved if the 98th percentile of the monitoring data is lower than 30 µg/m^3.

(d) The maximum 1-hour PM$_{2.5}$ concentration (i.e., excluding the eight highest 1-hour predicted concentrations) is estimated to be 45.9 µg/m^3 and 47.9 µg/m^3 for the Project Case and PDC, respectively.

1.6.7 Trace Air Compound Predictions

Tables 17 and 18 present the predicted 1-hour and annual PAH concentrations, respectively, at the selected receptors and the Saskatchewan receptor for each case. Tables 19 and 20 present the predicted 1-hour and annual trace metal concentrations, respectively, at the selected receptors and the Saskatchewan receptor. All of the predicted peak concentrations of PAH compounds and metals are below the AAAQOs or other criteria, as applicable. Several of the metal compound predictions decrease from the Project Case to the PDC. This is due to rounding errors. The PAHs and trace metals included in the tables were chosen based on screening performed for the health assessment. The effect of these compounds on Human Health (Section 3) and Wildlife Health (Appendix 3-VI) have been assessed separately.

Table 17 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	EAC [µg/m^3]	**Project Case [µg/m^3]**	**PDC [µg/m^3]**	**EAC [µg/m^3]**	**Project Case [µg/m^3]**	**PDC [µg/m^3]**	**EAC [µg/m^3]**	**Project Case [µg/m^3]**	**PDC [µg/m^3]**
Peak 1-Hour [µg/m^3]$^{(a)}$									
carcinogenic PAH group 1	0.000071	0.000102	0.000173	0.000072	0.000072	0.000337	0.000095	0.000213	0.000260
carcinogenic PAH group 2	0.000030	0.000038	0.000064	0.000068	0.000068	0.000156	0.000041	0.000077	0.000095
carcinogenic PAH group 3	0.000073	0.000073	0.000089	0.000022	0.000022	0.000059	0.000017	0.000034	0.000041
pyrenes and substituted pyrenes	0.000090	0.000090	0.000117	0.000117	0.000117	0.000167	0.000064	0.000066	0.000083
fluorenes/fluoranthenes and substituted	0.000446	0.000446	0.000478	0.000340	0.000340	0.000393	0.000193	0.000198	0.000228
acenaphthenes/acenaphthylenes	0.000445	0.000445	0.000465	0.000177	0.000178	0.000211	0.000096	0.000097	0.000118
anthracenes/phenanthrenes and substituted	0.000686	0.000686	0.000791	0.000409	0.000409	0.000596	0.000225	0.000239	0.000290
naphthalene and substituted naphthalenes	0.007160	0.007169	0.010617	0.005550	0.005552	0.013268	0.003598	0.006911	0.008457
1-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-chloronaphthalene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
biphenyls	0.013893	0.013893	0.013893	0.001412	0.001412	0.001412	0.000890	0.000890	0.000890
Total PAH	**0.022894**	**0.022943**	**0.026688**	**0.008168**	**0.008171**	**0.016601**	**0.005219**	**0.008726**	**0.010462**

Table 17 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak 1-Hour [µg/m³][(a)]									
carcinogenic PAH group 1	0.000311	0.000311	0.000311	0.000177	0.000196	0.000211	0.000492	0.000492	0.000492
carcinogenic PAH group 2	0.000111	0.000111	0.000111	0.000065	0.000072	0.000090	0.000175	0.000175	0.000175
carcinogenic PAH group 3	0.000046	0.000046	0.000046	0.000027	0.000030	0.000036	0.000073	0.000073	0.000073
pyrenes and substituted pyrenes	0.000077	0.000077	0.000081	0.000085	0.000085	0.000105	0.000122	0.000122	0.000122
fluorenes/fluoranthenes and substituted	0.000197	0.000198	0.000233	0.000264	0.000264	0.000303	0.000195	0.000195	0.000234
acenaphthenes/acenaphthylenes	0.000092	0.000092	0.000115	0.000130	0.000130	0.000156	0.000092	0.000092	0.000117
anthracenes/phenanthrenes and substituted	0.000300	0.000300	0.000302	0.000299	0.000299	0.000369	0.000473	0.000473	0.000473
naphthalene and substituted naphthalenes	0.009786	0.009786	0.009786	0.005757	0.006347	0.007778	0.015438	0.015438	0.015438
1-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-chloronaphthalene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
biphenyls	0.001193	0.001193	0.001193	0.001331	0.001331	0.001331	0.001293	0.001293	0.001293
Total PAH	**0.012115**	**0.012116**	**0.012179**	**0.008138**	**0.008756**	**0.010380**	**0.018354**	**0.018354**	**0.018418**

Table 17 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			La Loche, SK			Maximum Property Boundary		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak 1-Hour [µg/m³][(a)]									
carcinogenic PAH group 1	0.000062	0.000076	0.000196	0.000058	0.000058	0.000086	0.007496	0.007500	0.007531
carcinogenic PAH group 2	0.000030	0.000031	0.000073	0.000040	0.000040	0.000046	0.002673	0.002674	0.002686
carcinogenic PAH group 3	0.000020	0.000020	0.000030	0.000013	0.000013	0.000015	0.001114	0.001115	0.001119
pyrenes and substituted pyrenes	0.000044	0.000044	0.000067	0.000056	0.000056	0.000067	0.001858	0.001859	0.001868
fluorenes/fluoranthenes and substituted	0.000158	0.000158	0.000180	0.000164	0.000164	0.000187	0.002170	0.002171	0.002182
acenaphthenes/acenaphthylenes	0.000119	0.000120	0.000130	0.000080	0.000080	0.000095	0.001344	0.001345	0.001351
anthracenes/phenanthrenes and substituted	0.000190	0.000192	0.000251	0.000200	0.000200	0.000237	0.007213	0.007216	0.007249
naphthalene and substituted naphthalenes	0.002529	0.002557	0.006413	0.003237	0.003237	0.003765	0.235410	0.235520	0.236530
1-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-chloronaphthalene	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
biphenyls	0.003563	0.003563	0.003563	0.000159	0.000159	0.000159	0.007085	0.007085	0.007085
Total PAH	**0.006716**	**0.006761**	**0.010904**	**0.004009**	**0.004009**	**0.004660**	**0.266365**	**0.266486**	**0.267602**

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

Note: There are no Alberta Ambient Air Quality Objectives for PAH compounds.

Table 18 Existing and Approved Case, Project Case and Planned Development Case Annual Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak Annual Average [µg/m³][(a)]									
carcinogenic PAH group 1	0.000003	0.000004	0.000007	0.000003	0.000003	0.000009	0.000004	0.000009	0.000012
carcinogenic PAH group 2	0.000002	0.000002	0.000003	0.000002	0.000002	0.000004	0.000002	0.000004	0.000005
carcinogenic PAH group 3	0.000001	0.000001	0.000002	0.000001	0.000001	0.000002	0.000001	0.000002	0.000002
pyrenes and substituted pyrenes	0.000003	0.000003	0.000004	0.000003	0.000003	0.000005	0.000003	0.000004	0.000005
fluorenes/fluoranthenes and substituted	0.000010	0.000010	0.000012	0.000010	0.000010	0.000013	0.000007	0.000009	0.000011
acenaphthenes/acenaphthylenes	0.000007	0.000007	0.000008	0.000006	0.000006	0.000008	0.000004	0.000005	0.000006
anthracenes/phenanthrenes and substituted	0.000013	0.000014	0.000018	0.000012	0.000013	0.000020	0.000010	0.000015	0.000020
naphthalene and substituted naphthalenes	0.000190	0.000217	0.000325	0.000186	0.000202	0.000386	0.000184	0.000349	0.000468
1-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
biphenyls	0.000127	0.000127	0.000127	0.000053	0.000053	0.000053	0.000035	0.000035	0.000035
Total PAH	**0.000355**	**0.000386**	**0.000506**	**0.000275**	**0.000293**	**0.000499**	**0.000251**	**0.000432**	**0.000566**

Table 18 Existing and Approved Case, Project Case and Planned Development Case Annual Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator’s Residence		
	EAC [µg/m^3]	**Project Case [µg/m^3]**	**PDC [µg/m^3]**	**EAC [µg/m^3]**	**Project Case [µg/m^3]**	**PDC [µg/m^3]**	**EAC [µg/m^3]**	**Project Case [µg/m^3]**	**PDC [µg/m^3]**
Peak Annual Average [µg/m^3]$^{(a)}$									
carcinogenic PAH group 1	0.000005	0.000007	0.000010	0.000003	0.000006	0.000010	0.000008	0.000010	0.000013
carcinogenic PAH group 2	0.000003	0.000003	0.000005	0.000002	0.000003	0.000005	0.000003	0.000004	0.000006
carcinogenic PAH group 3	0.000001	0.000001	0.000002	0.000001	0.000001	0.000002	0.000002	0.000002	0.000002
pyrenes and substituted pyrenes	0.000003	0.000004	0.000005	0.000003	0.000004	0.000005	0.000004	0.000004	0.000006
fluorenes/fluoranthenes and substituted	0.000008	0.000009	0.000011	0.000009	0.000009	0.000012	0.000009	0.000009	0.000011
acenaphthenes/acenaphthylenes	0.000005	0.000005	0.000006	0.000005	0.000005	0.000007	0.000005	0.000006	0.000007
anthracenes/phenanthrenes and substituted	0.000012	0.000014	0.000019	0.000012	0.000014	0.000020	0.000015	0.000016	0.000021
naphthalene and substituted naphthalenes	0.000238	0.000292	0.000410	0.000190	0.000260	0.000410	0.000311	0.000368	0.000491
1-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
biphenyls	0.000048	0.000048	0.000048	0.000052	0.000052	0.000052	0.000047	0.000047	0.000047
Total PAH	**0.000324**	**0.000382**	**0.000516**	**0.000276**	**0.000353**	**0.000522**	**0.000403**	**0.000466**	**0.000604**

Table 18 Existing and Approved Case, Project Case and Planned Development Case Annual Polycyclic Aromatic Hydrocarbons Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			La Loche, SK			Maximum Property Boundary		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak Annual Average [µg/m³][(a)]									
carcinogenic PAH group 1	0.000003	0.000004	0.000007	0.000002	0.000003	0.000005	0.000311	0.000313	0.000317
carcinogenic PAH group 2	0.000002	0.000002	0.000003	0.000002	0.000002	0.000003	0.000112	0.000112	0.000114
carcinogenic PAH group 3	0.000001	0.000001	0.000002	0.000001	0.000001	0.000001	0.000047	0.000047	0.000048
pyrenes and substituted pyrenes	0.000003	0.000003	0.000004	0.000002	0.000002	0.000004	0.000079	0.000079	0.000081
fluorenes/fluoranthenes and substituted	0.000008	0.000008	0.000010	0.000007	0.000007	0.000009	0.000096	0.000097	0.000099
acenaphthenes/acenaphthylenes	0.000005	0.000005	0.000007	0.000004	0.000004	0.000005	0.000059	0.000060	0.000061
anthracenes/phenanthrenes and substituted	0.000011	0.000012	0.000016	0.000009	0.000009	0.000014	0.000306	0.000308	0.000313
naphthalene and substituted naphthalenes	0.000165	0.000193	0.000300	0.000140	0.000144	0.000257	0.009841	0.009906	0.010037
1-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2-chloronaphthalene	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
biphenyls	0.000081	0.000081	0.000081	0.000008	0.000008	0.000008	0.000100	0.000100	0.000100
Total PAH	**0.000278**	**0.000309**	**0.000430**	**0.000175**	**0.000179**	**0.000307**	**0.010952**	**0.011023**	**0.011170**

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

Note: There are no Alberta Ambient Air Quality Objectives for PAH compounds.

Table 19 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Trace Metal Predictions at Selected Receptors

Parameter	**Conklin**			Janvier/Chard (IR 194)			**Winefred Lake (IR 194B)**		
	EAC [µg/m³]	**Project Case [µg/m³]**	**PDC [µg/m³]**	**EAC [µg/m³]**	**Project Case [µg/m³]**	**PDC [µg/m³]**	**EAC [µg/m³]**	**Project Case [µg/m³]**	**PDC [µg/m³]**
Peak 1-Hour [µg/m³](a)									
aluminum	0.002499	0.002499	0.002636	0.004875	0.004875	0.005209	0.002747	0.002747	0.002961
antimony	0.000135	0.000135	0.000135	0.000165	0.000165	0.000165	0.000170	0.000170	0.000170
arsenic(b)	0.000062	0.000063	0.000081	0.000100	0.000100	0.000114	0.000080	0.000166	0.000176
barium	0.000888	0.000925	0.001289	0.001516	0.001518	0.001813	0.001094	0.003641	0.003845
beryllium	0.000004	0.000005	0.000006	0.000008	0.000008	0.000009	0.000005	0.000010	0.000011
cadmium	0.000412	0.000412	0.000710	0.000938	0.000938	0.001326	0.000486	0.000920	0.000967
chromium(b)	0.001322	0.001322	0.001424	0.002457	0.002458	0.002593	0.001437	0.001501	0.001586
cobalt	0.000197	0.000197	0.000211	0.000264	0.000265	0.000319	0.000246	0.000246	0.000262
copper	0.000264	0.000266	0.000359	0.000486	0.000486	0.000590	0.000325	0.000705	0.000746
lead(b)	0.000241	0.000243	0.000305	0.000452	0.000452	0.000527	0.000282	0.000416	0.000441
manganese(b)	0.000479	0.000479	0.000530	0.000940	0.000940	0.001007	0.000542	0.000559	0.000602
mercury	0.000044	0.000054	0.000075	0.000078	0.000078	0.000099	0.000056	0.000215	0.000227
molybdenum	0.000359	0.000361	0.000459	0.000670	0.000671	0.000744	0.000433	0.000911	0.000964
nickel(b)	0.002744	0.002749	0.003013	0.004573	0.004574	0.005310	0.003769	0.003776	0.004359
selenium	0.000536	0.000536	0.000536	0.000869	0.000869	0.000870	0.000576	0.000576	0.000577
silver	0.000061	0.000061	0.000103	0.000137	0.000137	0.000191	0.000068	0.000068	0.000106
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000149	0.000149	0.000149	0.000255	0.000255	0.000255	0.000146	0.000146	0.000146
vanadium	0.005206	0.005214	0.005271	0.003878	0.003879	0.005810	0.007274	0.007275	0.007287
zinc	0.008948	0.009019	0.011717	0.018217	0.018231	0.020462	0.012093	0.024017	0.025431
Total metals	**0.024550**	**0.024688**	**0.029007**	**0.040878**	**0.040898**	**0.047413**	**0.031831**	**0.048067**	**0.050864**

Table 19 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Trace Metal Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator's Residence		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak 1-Hour [µg/m^3](a)									
aluminum	0.002792	0.002792	0.002951	0.003810	0.003810	0.004084	0.002790	0.002790	0.002956
antimony	0.000136	0.000136	0.000136	0.000167	0.000167	0.000167	0.000144	0.000144	0.000144
arsenic(b)	0.000081	0.000083	0.000090	0.000088	0.000089	0.000106	0.000126	0.000126	0.000127
barium	0.001706	0.001737	0.001632	0.001161	0.001545	0.001667	0.002657	0.002659	0.002659
beryllium	0.000005	0.000006	0.000006	0.000006	0.000006	0.000007	0.000007	0.000007	0.000007
cadmium	0.000467	0.000475	0.000656	0.000639	0.000639	0.000969	0.000664	0.000665	0.000727
chromium(b)	0.001381	0.001531	0.001627	0.001896	0.001897	0.001986	0.001399	0.001513	0.001595
cobalt	0.000224	0.000224	0.000246	0.000254	0.000254	0.000283	0.000233	0.000234	0.000255
copper	0.000347	0.000353	0.000382	0.000375	0.000376	0.000448	0.000515	0.000515	0.000518
lead(b)	0.000224	0.000268	0.000315	0.000345	0.000345	0.000399	0.000307	0.000307	0.000309
manganese(b)	0.000501	0.000542	0.000582	0.000719	0.000719	0.000768	0.000511	0.000542	0.000580
mercury	0.000100	0.000102	0.000096	0.000056	0.000091	0.000099	0.000157	0.000157	0.000157
molybdenum	0.000444	0.000466	0.000526	0.000515	0.000515	0.000558	0.000664	0.000665	0.000665
nickel(b)	0.003633	0.003642	0.004251	0.003960	0.003966	0.005046	0.003751	0.003758	0.004367
selenium	0.000563	0.000563	0.000564	0.000660	0.000660	0.000661	0.000553	0.000553	0.000554
silver	0.000062	0.000062	0.000090	0.000097	0.000097	0.000140	0.000065	0.000065	0.000094
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000148	0.000148	0.000148	0.000194	0.000194	0.000194	0.000152	0.000152	0.000152
vanadium	0.005434	0.005435	0.005427	0.005294	0.005294	0.005464	0.005610	0.005612	0.005620
zinc	0.011797	0.013086	0.014791	0.014473	0.014487	0.015861	0.017511	0.017523	0.017523
Total metals	**0.030044**	**0.031650**	**0.034516**	**0.034710**	**0.035152**	**0.038908**	**0.037817**	**0.037986**	**0.039008**

Table 19 Existing and Approved Case, Project Case and Planned Development Case 1-Hour Trace Metal Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			La Loche, SK			Maximum Property Boundary		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak 1-Hour [µg/m³](a)									
aluminum	0.002613	0.002613	0.002729	0.002581	0.002581	0.002588	0.002913	0.002913	0.003112
antimony	0.000132	0.000132	0.000132	0.000141	0.000141	0.000141	0.000171	0.000171	0.000171
arsenic(b)	0.000065	0.000065	0.000123	0.000058	0.000058	0.000062	0.000965	0.002638	0.002646
barium	0.001090	0.001200	0.002675	0.000883	0.000883	0.001008	0.021227	0.058028	0.058199
beryllium	0.000005	0.000005	0.000007	0.000004	0.000004	0.000005	0.000058	0.000158	0.000159
cadmium	0.000364	0.000364	0.000679	0.000381	0.000381	0.000601	0.005308	0.014519	0.014562
chromium(b)	0.001455	0.001455	0.001509	0.001272	0.001272	0.001278	0.006754	0.018467	0.018521
cobalt	0.000185	0.000186	0.000196	0.000208	0.000208	0.000217	0.000405	0.001110	0.001114
copper	0.000260	0.000262	0.000520	0.000258	0.000258	0.000312	0.004101	0.011213	0.011246
lead(b)	0.000232	0.000234	0.000306	0.000228	0.000228	0.000272	0.002412	0.006597	0.006616
manganese(b)	0.000556	0.000556	0.000581	0.000487	0.000487	0.000489	0.001833	0.005014	0.005029
mercury	0.000064	0.000071	0.000158	0.000045	0.000045	0.000052	0.001254	0.003429	0.003439
molybdenum	0.000368	0.000368	0.000669	0.000346	0.000346	0.000377	0.005307	0.014507	0.014550
nickel(b)	0.002908	0.002914	0.003243	0.002699	0.002699	0.002733	0.010131	0.027795	0.027877
selenium	0.000778	0.000778	0.000779	0.000664	0.000664	0.000664	0.000682	0.000682	0.000684
silver	0.000064	0.000064	0.000107	0.000056	0.000056	0.000080	0.000077	0.000077	0.000110
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000181	0.000181	0.000181	0.000166	0.000166	0.000166	0.000159	0.000159	0.000159
vanadium	0.004645	0.004645	0.004652	0.002703	0.002706	0.002728	0.011096	0.030648	0.030738
zinc	0.008609	0.008685	0.017654	0.009062	0.009062	0.010087	0.139910	0.382480	0.383610
Total metals	**0.024575**	**0.024776**	**0.036900**	**0.022242**	**0.022244**	**0.023859**	**0.214764**	**0.580606**	**0.582541**

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

(b) There are no 1-hour AAAQO for metal compounds except for arsenic (0.1 µg/m³), chromium (1 µg/m³), lead (1.5 µg/m³), manganese (2 µg/m³) and nickel (6 µg/m³).

Table 20 Existing and Approved Case, Project Case and Planned Development Case Annual Trace Metal Predictions at Selected Receptors

Parameter	Conklin			Janvier/Chard (IR 194)			Winefred Lake (IR 194B)		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak Annual Average [µg/m³][(a)]									
aluminum	0.000065	0.000065	0.000071	0.000095	0.000095	0.000105	0.000068	0.000068	0.000075
antimony	0.000002	0.000002	0.000002	0.000003	0.000003	0.000003	0.000002	0.000002	0.000002
arsenic[(b)]	0.000003	0.000003	0.000005	0.000004	0.000004	0.000006	0.000004	0.000008	0.000009
barium	0.000045	0.000057	0.000094	0.000059	0.000068	0.000114	0.000070	0.000157	0.000188
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001
cadmium	0.000019	0.000022	0.000036	0.000027	0.000029	0.000048	0.000026	0.000048	0.000061
chromium	0.000039	0.000043	0.000055	0.000055	0.000058	0.000074	0.000048	0.000076	0.000087
cobalt	0.000005	0.000006	0.000007	0.000008	0.000008	0.000011	0.000007	0.000008	0.000010
copper	0.000012	0.000014	0.000022	0.000017	0.000018	0.000028	0.000017	0.000034	0.000041
lead	0.000009	0.000011	0.000016	0.000013	0.000014	0.000021	0.000013	0.000023	0.000027
manganese[(b)]	0.000015	0.000016	0.000020	0.000022	0.000022	0.000028	0.000018	0.000025	0.000029
mercury	0.000002	0.000003	0.000005	0.000003	0.000004	0.000006	0.000004	0.000009	0.000011
molybdenum	0.000015	0.000018	0.000027	0.000020	0.000022	0.000034	0.000021	0.000043	0.000051
nickel[(b)]	0.000106	0.000111	0.000143	0.000145	0.000149	0.000206	0.000138	0.000179	0.000210
selenium	0.000011	0.000011	0.000011	0.000016	0.000016	0.000016	0.000012	0.000012	0.000012
silver	0.000002	0.000002	0.000003	0.000003	0.000003	0.000004	0.000002	0.000002	0.000003
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000003	0.000005	0.000005	0.000005	0.000003	0.000003	0.000003
vanadium	0.000114	0.000120	0.000165	0.000129	0.000133	0.000225	0.000174	0.000219	0.000266
zinc	0.000408	0.000484	0.000734	0.000547	0.000604	0.000916	0.000578	0.001146	0.001358
Total metals	**0.000877**	**0.000991**	**0.001419**	**0.001170**	**0.001256**	**0.001850**	**0.001207**	**0.002063**	**0.002442**

Table 20 Existing and Approved Case, Project Case and Planned Development Case Annual Trace Metal Predictions at Selected Receptors (continued)

Parameter	Hunter/Trapper A			Hunter/Trapper B			Operator’s Residence		
	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]	EAC [µg/m³]	Project Case [µg/m³]	PDC [µg/m³]
Peak Annual Average [µg/m³][a]									
aluminum	0.000068	0.000068	0.000074	0.000083	0.000083	0.000091	0.000069	0.000069	0.000076
antimony	0.000002	0.000002	0.000002	0.000003	0.000003	0.000003	0.000002	0.000002	0.000002
arsenic[b]	0.000005	0.000006	0.000008	0.000004	0.000005	0.000007	0.000005	0.000006	0.000008
barium	0.000085	0.000110	0.000147	0.000058	0.000094	0.000140	0.000092	0.000120	0.000156
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
cadmium	0.000029	0.000036	0.000050	0.000024	0.000033	0.000051	0.000031	0.000039	0.000052
chromium	0.000053	0.000061	0.000074	0.000051	0.000062	0.000078	0.000056	0.000065	0.000077
cobalt	0.000007	0.000007	0.000009	0.000007	0.000008	0.000010	0.000007	0.000007	0.000009
copper	0.000020	0.000025	0.000033	0.000016	0.000023	0.000032	0.000022	0.000027	0.000035
lead	0.000014	0.000017	0.000022	0.000012	0.000016	0.000023	0.000015	0.000018	0.000023
manganese[b]	0.000019	0.000021	0.000025	0.000019	0.000023	0.000028	0.000020	0.000022	0.000026
mercury	0.000005	0.000006	0.000008	0.000003	0.000005	0.000008	0.000005	0.000007	0.000009
molybdenum	0.000025	0.000031	0.000041	0.000019	0.000028	0.000040	0.000027	0.000034	0.000043
nickel[b]	0.000137	0.000149	0.000183	0.000136	0.000153	0.000199	0.000142	0.000156	0.000190
selenium	0.000012	0.000012	0.000012	0.000014	0.000014	0.000015	0.000012	0.000012	0.000012
silver	0.000002	0.000002	0.000003	0.000003	0.000003	0.000004	0.000002	0.000002	0.000003
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004	0.000003	0.000003	0.000003
vanadium	0.000156	0.000169	0.000221	0.000135	0.000154	0.000225	0.000162	0.000177	0.000230
zinc	0.000672	0.000838	0.001089	0.000522	0.000760	0.001071	0.000724	0.000910	0.001152
Total metals	**0.001314**	**0.001564**	**0.002005**	**0.001113**	**0.001471**	**0.002029**	**0.001398**	**0.001678**	**0.002109**

Table 20 Existing and Approved Case, Project Case and Planned Development Case Annual Trace Metal Predictions at Selected Receptors (continued)

Parameter	Christina Lake Lodge			La Loche, SK			Maximum Property Boundary		
	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]	EAC [µg/m^3]	Project Case [µg/m^3]	PDC [µg/m^3]
Peak Annual Average [µg/m^3](a)									
aluminum	0.000064	0.000064	0.000070	0.000081	0.000081	0.000090	0.000077	0.000077	0.000084
antimony	0.000002	0.000002	0.000002	0.000004	0.000004	0.000004	0.000002	0.000002	0.000002
arsenic(b)	0.000003	0.000003	0.000005	0.000003	0.000003	0.000004	0.000021	0.000035	0.000037
barium	0.000047	0.000059	0.000097	0.000043	0.000045	0.000063	0.000453	0.000751	0.000798
beryllium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000002	0.000002
cadmium	0.000019	0.000023	0.000036	0.000020	0.000021	0.000032	0.000122	0.000196	0.000213
chromium	0.000039	0.000043	0.000056	0.000045	0.000046	0.000053	0.000172	0.000268	0.000284
cobalt	0.000006	0.000006	0.000007	0.000009	0.000009	0.000010	0.000014	0.000020	0.000022
copper	0.000012	0.000015	0.000023	0.000013	0.000013	0.000018	0.000091	0.000149	0.000159
lead	0.000010	0.000011	0.000016	0.000011	0.000011	0.000014	0.000056	0.000090	0.000097
manganese(b)	0.000015	0.000016	0.000020	0.000019	0.000019	0.000022	0.000052	0.000078	0.000083
mercury	0.000003	0.000003	0.000006	0.000002	0.000002	0.000003	0.000027	0.000044	0.000047
molybdenum	0.000015	0.000018	0.000028	0.000015	0.000016	0.000020	0.000117	0.000192	0.000204
nickel(b)	0.000107	0.000113	0.000145	0.000143	0.000144	0.000168	0.000318	0.000458	0.000501
selenium	0.000011	0.000011	0.000011	0.000015	0.000015	0.000015	0.000014	0.000017	0.000017
silver	0.000002	0.000002	0.000003	0.000002	0.000002	0.000004	0.000002	0.000002	0.000003
strontium	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
tin	0.000003	0.000003	0.000003	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
vanadium	0.000117	0.000123	0.000170	0.000097	0.000098	0.000136	0.000351	0.000496	0.000558
zinc	0.000413	0.000499	0.000754	0.000413	0.000427	0.000552	0.003107	0.005076	0.005392
Total metals	**0.000887**	**0.001015**	**0.001453**	**0.000940**	**0.000962**	**0.001211**	**0.005002**	**0.007958**	**0.008507**

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

(b) There are no annual AAAQO for metal compounds except for arsenic (0.01 µg/m^3), manganese (0.2 µg/m^3) and nickel (0.05 µg/m^3).

2 REFERENCES

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CASA (Clean Air Strategic Alliance). 2003. Guidance Document for the Management of Fine Particulate Matter and Ozone in Alberta. September 2003.

Cheng, L. 2001. Background PAI for the Oil Sands Region, Determined for 1995 using the RELAD model and all sources within the Oil Sands Region set to zero. May 8, 2001.

2.1 PERSONAL COMMUNICATION

Cheng, L. 2005. Alberta Environment, Environmental Policy Branch. Edmonton, AB. Telephone conversation with Greg Unrau, Golder Associates Ltd. April 19, 2005.

APPENDIX 3-IV

UPSET CONDITIONS

TABLE OF CONTENTS

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LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Three upset scenarios were included as part of the MEG Energy Corp. (MEG) Christina Lake Regional Project – Phase 3 (the Project) Air Quality Assessment (Section 1). They are as follows:

- Upset Scenario 1 – A fire occurs in the inlet area associated with either one of the two process trains at Plant 3A or 3B. Vessels are blocked when the fire starts. As the vessels heat up, the pressure inside the vessels would rise and eventually be relieved through pressure safety valves to the flare system.
- Upset Scenario 2 – A blocked gas flow from the amine sweetening unit regenerator column results in a pressure rise in the regeneration column. The pressure is relieved through the flare system. This upset can occur in either one of the two process trains at Plant 3A or 3B.
- Upset Scenario 3 – A blocked gas flow from the Sulphur Recovery Unit (SRU) at the Central Plant Site causes the pressure to rise inside the SRU. Pressure is relieved by safely disposing the gas in the Phase 2B flare.

The following sections provide detailed analyses of each of the upset scenarios described above.

2 UPSET SCENARIO 1: VENTING DURING A FIRE IN THE INLET AREA AT PLANT 3A OR 3B

Upset Scenario 1 can occur in either one of the process trains at Plant 3A or 3B. The upset gas could be safely vented by any one of the four flares at Plant 3A or 3B. In the assessed scenario, the gas is diverted to Flare 1 in Plant 3A. This flare was chosen due to its proximity to both the fenceline and the nearest selected receptor (Winefred Lake – IR 194B).

During this upset scenario, some of the steam generators and heaters associated with the affected process train may still be running. For the purpose of this assessment, it was assumed that all steam generators and heaters associated with the process train would continue to operate. The probability of this upset is once in 20 years, and the duration could be up to 30 minutes.

2.1 EMISSIONS

Table 1 summarizes the composition and net heating value of the vapour stream being sent to the flare. The gas would contain a high percentage of steam (86.5 mole percent) and cannot sustain combustion. Therefore, the gas will be vented through the flare.

Table 1 Upset Scenario 1 Summary

Component	Value
emission source	Phase 3A Flare 1
venting frequency	1 per 20 years
venting duration	30 minutes
maximum vent gas flow rate [m³/min]	3,023.8
molecular weight	18.2
Flare Gas Composition [mole fraction]	
N_2	0.001
Carbon Monoxide (CO_2)	0.004
Hydrogen Sulphide (H_2S)	0.001
C_1	0.125
C_2	0.000
C_3	0.000
i-C_4	0.000
n-C_4	0.000
i-C_5	0.000
n-C_5	0.000
C_6	0.000
C_{7+}	0.004
Water (H_2O)	0.865
Total	**1.000**
net heating value [MJ/m³]	5.02

Table 2 summarizes the stack parameters and the emission rate used in the dispersion modelling for Upset Scenario 1. As per Alberta Environment (AENV) flaring guidelines (AENV 2003a), the emission rate was adjusted to account for the venting duration.

Table 2 Upset Scenario 1 Stack Parameters and Emission Rates

Component	Value
physical height [m]	54
physical diameter [m]	0.762
exit velocity [m/s]	188.8
exit temperature [K]	493.2
H_2S emission rate [g/s]	60.82

2.2 MODELLING RESULTS

Table 3 presents the predicted ground-level hydrogen sulphide (H_2S) concentrations for Upset Scenario 1. Compliance with the Alberta Ambient Air Quality Objectives (AAAQOs) is based on the maximum prediction (AENV 2003b). For Upset Scenario 1, the maximum prediction, which corresponds to the 0.01 percentile value, exceeds the 1-hour H_2S AAAQO of 14 µg/m³ for 311 hours, or 3.5% of the year.

Table 3 Upset Scenario 1 Predicted 1-Hour Hydrogen Sulphide Concentrations

Area of Interest[a]	1-Hour Predictions [µg/m³]							
	Peak	0.001%	0.01%[b]	0.1%	1%	2%	5%	10%
predicted concentration including developed areas	154.3	151.0	127.9	61.7	26.6	20.1	10.2	3.4
predicted concentration excluding developed areas	154.3	151.0	127.9	61.7	26.6	20.1	10.2	3.4

[a] Developed areas include the Project plant sites.

[b] The maximum predicted concentration corresponds to the 0.01 percentile value.

The maximum 1-hour H_2S predictions for Upset Scenario 1 are presented in Figure 1 and the likelihoods of the maximum 1-hour H_2S predictions exceeding the AAAQO are presented in Figure 2. The likelihoods represent the percentage of time during a modelled year that the corresponding predicted concentrations may occur. These likelihood values are conservative, as they do not account for the likelihood of the upset event actually occurring. This upset event is expected to occur once every 20 years for about 30 minutes.

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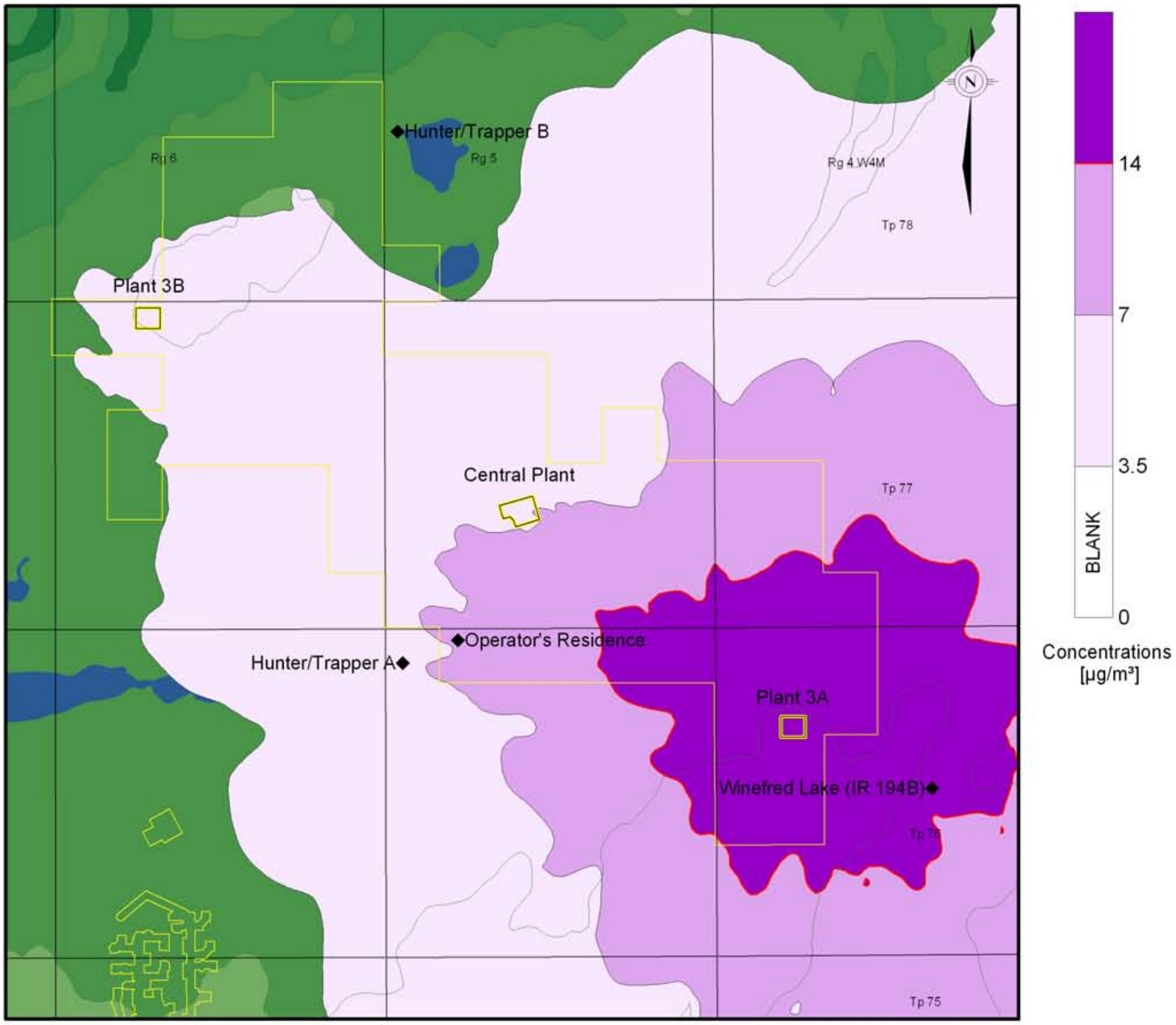

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SCALE KILOMETRES

LEGEND

🟩 ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.

🟩 MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.

🟩 MEG PLANT SITES

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.) USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 1
MAXIMUM 1-HOUR H_2S PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 1

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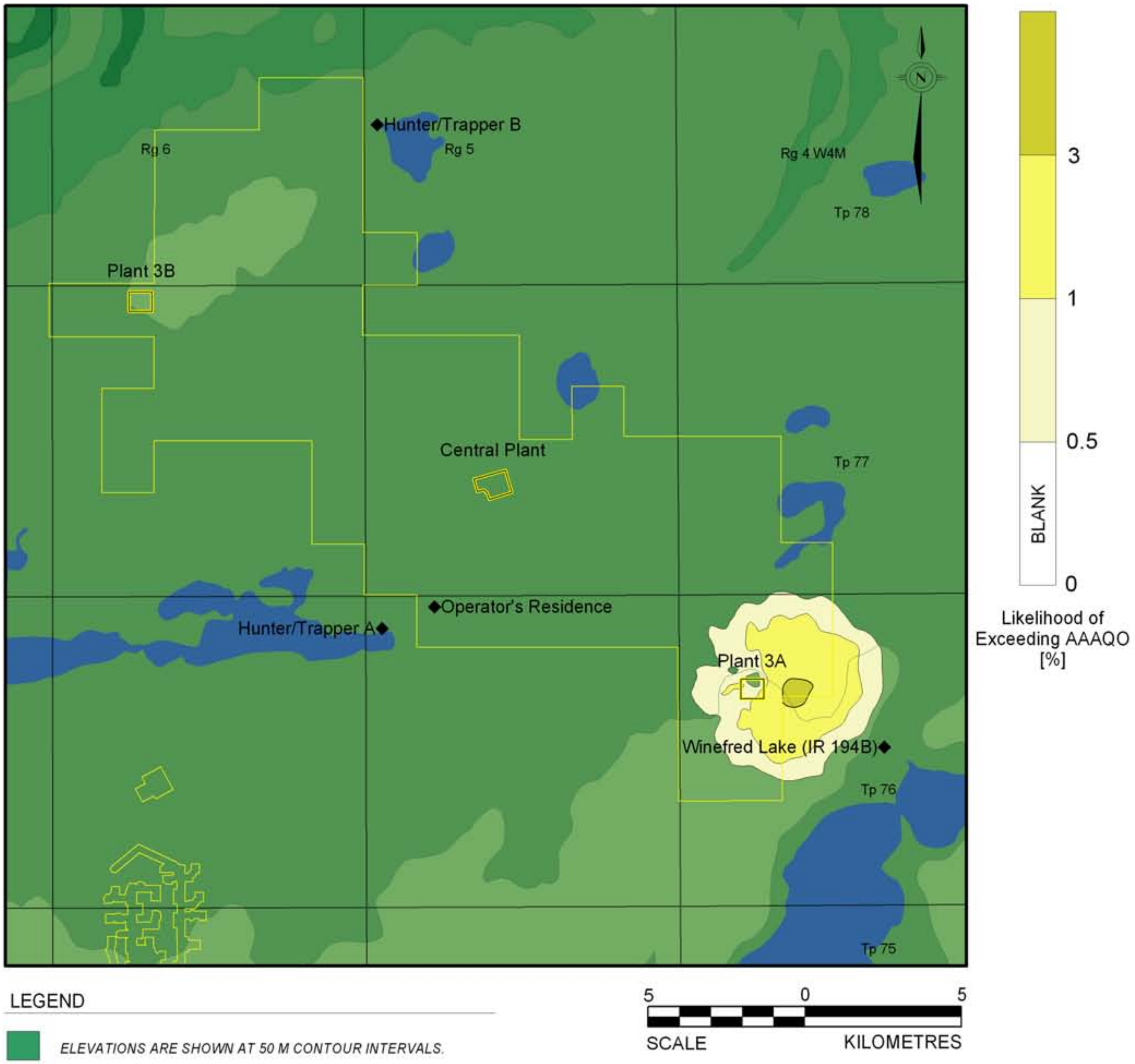

LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.

MEG PLANT SITES

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 1
LIKELIHOOD OF MAXIMUM 1-HOUR H_2S PREDICTIONS EXCEEDING AAAQO

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 2

The selected receptors were also included in the Upset Scenario 1 modelling. The selected receptors that are located in the Local Study Area (LSA) are shown in Figures 1 to 11. The predicted H_2S concentrations at the selected receptors are presented in Table 4. The maximum predictions (the 0.01 percentile value) are below the 1-hour H_2S AAAQO of 14 µg/m³ at all receptors, except Winefred Lake (IR 194B) and the Maximum Property Boundary. However, there are only 12 exceedances at Winefred Lake (IR 194B) and at the Maximum Property Boundary location, there are 185 exceedances, which correspond to 2.1% of the year. The peak and maximum prediction at La Loche, Saskatchewan are below the AAAQO.

Table 4 Upset Scenario 1 Predicted 1-Hour Hydrogen Sulphide Concentrations at Selected Receptors

Receptor	1-Hour Predictions [µg/m³]							
	Peak	0.001%	0.01%[a]	0.1%	1%	2%	5%	10%
Conklin	3.0	3.0	2.7	2.0	0.9	0.4	0.1	0.0
Janvier/Chard (IR 194)	4.9	4.7	3.2	1.9	0.7	0.3	0.1	0.0
Winefred Lake (IR 194B)	28.6	28.4	26.6	19.1	9.9	7.9	4.4	1.4
Cabin A	16.3	15.6	9.8	6.1	2.0	0.9	0.2	0.0
Cabin B	3.6	3.6	3.5	2.8	1.1	0.5	0.1	0.0
Operator's Residence	10.0	9.9	9.8	7.4	2.5	1.0	0.2	0.0
Christina Lake Lodge	3.3	3.3	3.0	2.2	0.9	0.5	0.1	0.0
La Loche, SK	1.0	1.0	0.8	0.6	0.3	0.2	0.1	0.0
Maximum Property Boundary	105.7	103.4	86.6	45.5	22.3	14.9	5.2	0.4

[a] The maximum predicted concentration corresponds to the 0.01 percentile value.

3 UPSET SCENARIO 2: BLOCKED FLOW FROM THE AMINE SWEETENING UNIT REGENERATOR COLUMN AT PLANT 3A OR 3B

Upset Scenario 2 could occur in either one of the two process trains at Plant 3A or 3B. The diverted gas stream could be combusted in any one of the four flares at Plant 3A or 3B. As in Upset Scenario 1, Flare 1 at Plant 3A was chosen to handle the relieved gas due to its proximity to both the fenceline and the nearest selected receptor (Winefred Lake – IR 194B).

It was assumed that all steam generators and heaters associated with the affected process train are still operating during the upset. The upset probability is once per year, and it could last for about 10 minutes.

3.1 EMISSIONS

The gas from the amine sweetening unit regenerator column would have a net heating value below 12 MJ/m³, therefore, supplemental fuel gas would be required to increase the net heating value to a minimum of 12 MJ/m³ during this upset condition. Table 5 summarizes the composition and net heating value of the flared gas.

Table 5 **Upset Scenario 2 Summary**

Component	Value
emission source	Phase 3A Flare 1
flaring frequency	1 per year
flaring duration	10 minutes
flare gas flow rate [m³/min]	13.1
molecular weight	35.2
Flare Gas Composition [mole fraction]	
N_2	0.001
CO_2	0.490
H_2S	0.298
C_1	0.161
C_2	0.000
C_3	0.000
i-C_4	0.000
n-C_4	0.000
i-C_5	0.000
n-C_5	0.000
C_6	0.000
C_{7+}	0.000
H_2O	0.050
Total	**1.000**
net heating value [MJ/m³]	12.00

Three flow rates have been considered as part of the flaring assessment, as per the Alberta Energy and Utilities Board's (EUB) (now the Alberta Energy Resources Conservation Board (ERCB)) Directive 060, Upstream Petroleum Industry Flaring, Incinerating and Venting (EUB 2006). Directive 060 provides regulatory requirements and guidelines for flaring, incinerating and venting in Alberta, as well as procedural information for flare permit requests, dispersion modelling and measuring and reporting of flared, incinerated and vented gas. The three flow rates considered are:

- flaring at the maximum flow rate (Q_{max});
- flaring at 50% of the maximum flow rate ($Q_{max}/2$); and
- flaring at 12.5% of the maximum flow rate ($Q_{max/}/8$).

Although EUB Directive 060 suggests using an average flow rate as part of a sensitivity analysis, an average flow rate was not available. Therefore, flaring at 50% of the maximum flow rate (i.e., $Q_{max}/2$) was assumed to be representative of the average flow rate.

For the purpose of modelling flare stack releases, a series of pseudo stack characteristics were determined. The pseudo stack parameters allow for the simulation of the unconfined combustion of a flaring event with the CALPUFF dispersion model. The pseudo stack parameters were derived using the ERCB flaring spreadsheet (ERCB 2007, Website). The spreadsheet tool provides guidance on appropriate flow rates during flaring events. If the flow rates are unlikely, the spreadsheet will identify them. Therefore, flaring at lower flow rates ($Q_{max}/2$ and $Q_{max}/8$) were not modelled.

Table 6 summarizes the flaring parameters and emission rates for Upset Scenario 2. As per AENV flaring guidance (AENV 2003a), the emission rate was adjusted to account for the flaring duration.

Table 6 Upset Scenario 2 Flaring Parameters and Emission Rates

Component	Q_{max}
physical height [m]	54
pseudo-height [m][(a)]	52.729
physical diameter [m]	0.762
pseudo-diameter [m][(a)]	1.115
pseudo-exit velocity [m/s][(a)]	1.09
pseudo-temperature [K][(a)]	2,285.5
SO_2 emission rate [g/s][(b)]	175.1
H_2S emission rate [g/s][(c)]	1.753

(a) Assumed for the purposes of dispersion modelling.

(b) It was assumed that up to 100% of the inlet sulphur to the flare (in the form of hydrogen sulphide, H_2S) can be converted to SO_2.

(c) It was assumed that up to 2% of the inlet sulphur to the flare is not oxidized, and would be released in the form of H_2S.

3.2 MODELLING RESULTS

Table 7 presents the predicted ground-level SO_2 concentrations for Upset Scenario 2. There are predicted exceedances of the 1-hour SO_2 AAAQO of 450 µg/m^3. However, only 44 hours, or 0.5% of the maximum predictions (the 0.01 percentile value), exceed 450 µg/m^3. The maximum 1-hour SO_2 predictions for Upset Scenario 2 are presented in Figure 3 and the likelihoods of the maximum 1-hour SO_2 predictions exceeding the AAAQO are presented in Figure 4. The likelihoods represent the percentage of time during a modelled year that the corresponding predicted concentrations are likely to occur. Therefore, these likelihood values are conservative, as they assume the event is occurring continuously all year. In reality, the upset event could occur once every year for 10 minutes.

Table 7 Upset Scenario 2 Predicted 1-Hour Hydrogen Sulphide Concentrations

Area of Interest(a)	1-Hour Predictions [µg/m^3]							
	Peak	0.001%	0.01%(b)	0.1%	1%	2%	5%	10%
predicted concentration including developed areas	2,977.2	2,974.7	2,952.5	1,458.0	372.7	267.9	144.8	68.4
predicted concentration excluding developed areas	1,427.5	1,387.9	1,222.2	831.6	372.7	267.9	144.8	68.4

(a) Developed areas include the Project plant sites.

(b) The maximum predicted concentration corresponds to the 0.01 percentile value.

Table 8 presents the predicted ground-level H2S concentrations for Upset Scenario 2. The maximum prediction excluding developed areas is 8.7 µg/m^3, which is below the 1-hour H2S AAAQO of 14 µg/m^3. The maximum 1-hour H_2S predictions for Upset Scenario 2 are presented in Figure 5.

Table 8 Upset Scenario 2 Predicted 1-Hour Hydrogen Sulphide Concentrations

Area of Interest(a)	Peak Concentration(b) [µg/m^3]	Maximum Concentration(c) [µg/m^3]
predicted concentration including developed areas	29.8	14.7
predicted concentration excluding developed areas	14.3	8.7

(a) Developed areas include the Project plant sites.

(b) The peak concentrations represent the highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003b) when determining compliance with the AAAQOs.

(c) The maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta Air Quality Model Guideline (AENV 2003b).

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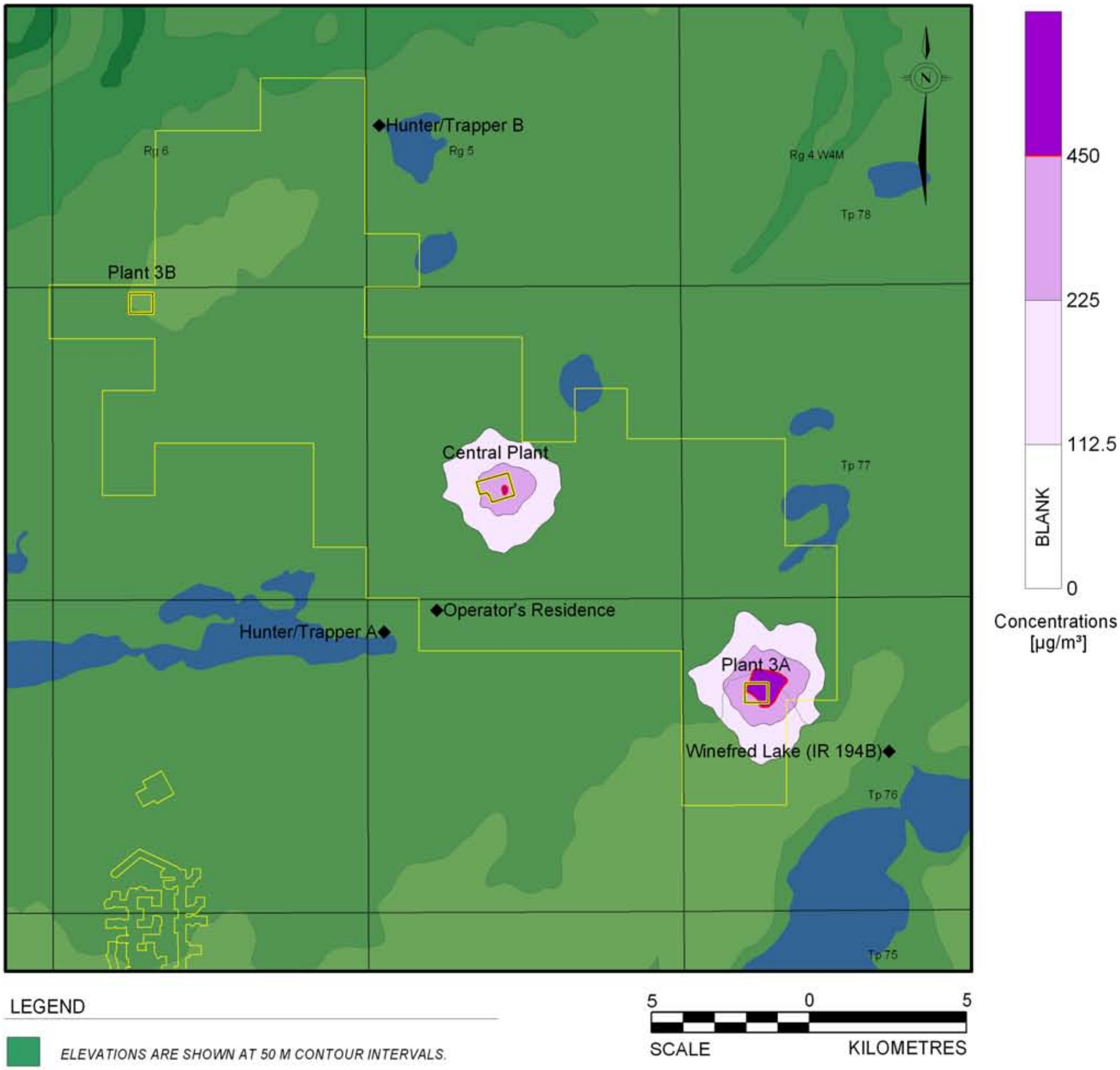

LEGEND

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MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.

MEG PLANT SITES

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 2
MAXIMUM 1-HOUR SO_2 PREDICTIONS

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.)
USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 3

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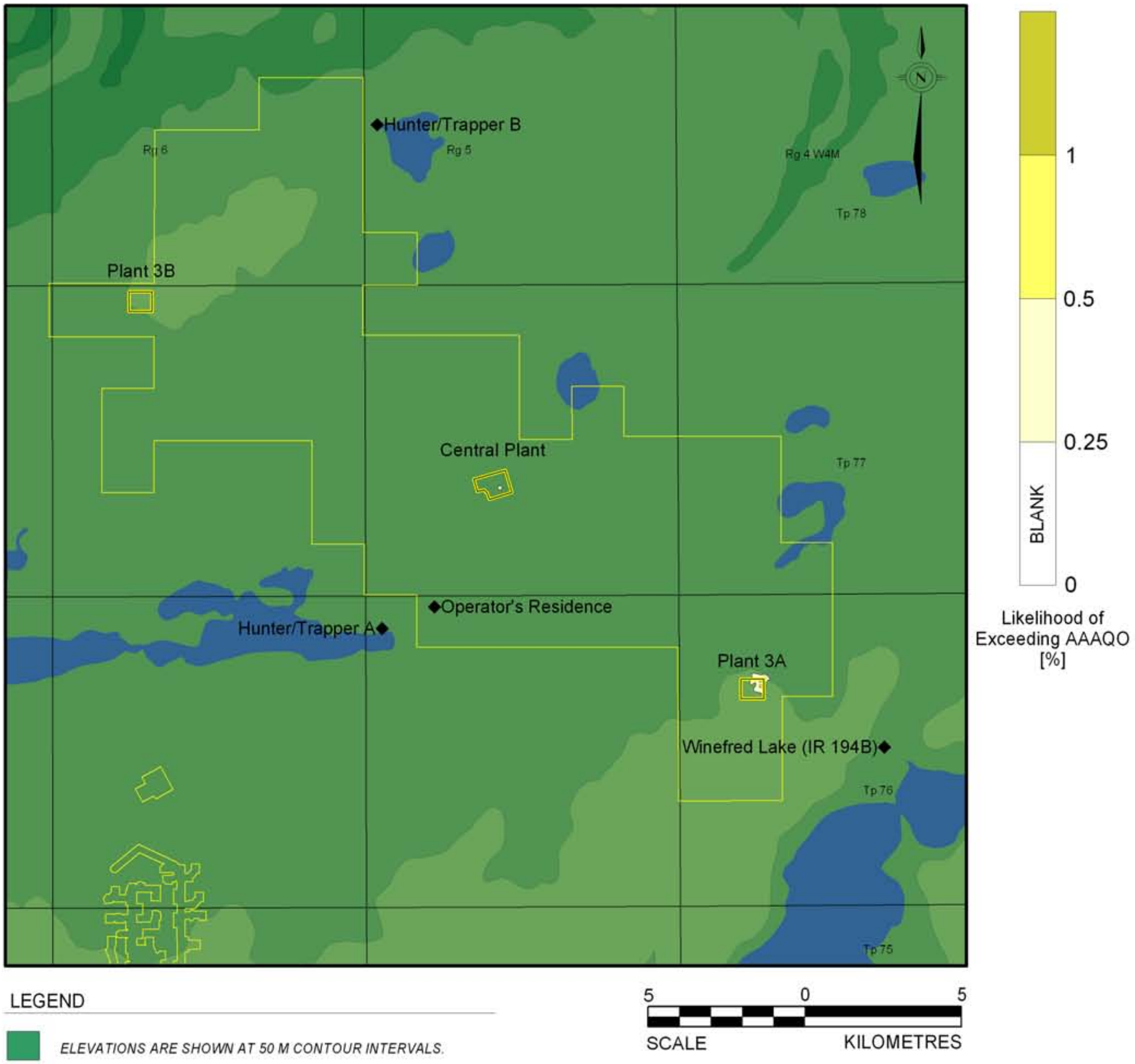

LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.*

🟩 *MEG PLANT SITES*

SCALE: AS SHOWN

REFERENCE

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DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 2
LIKELIHOOD OF MAXIMUM 1-HOUR SO_2
PREDICTIONS EXCEEDING AAAQO

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 4

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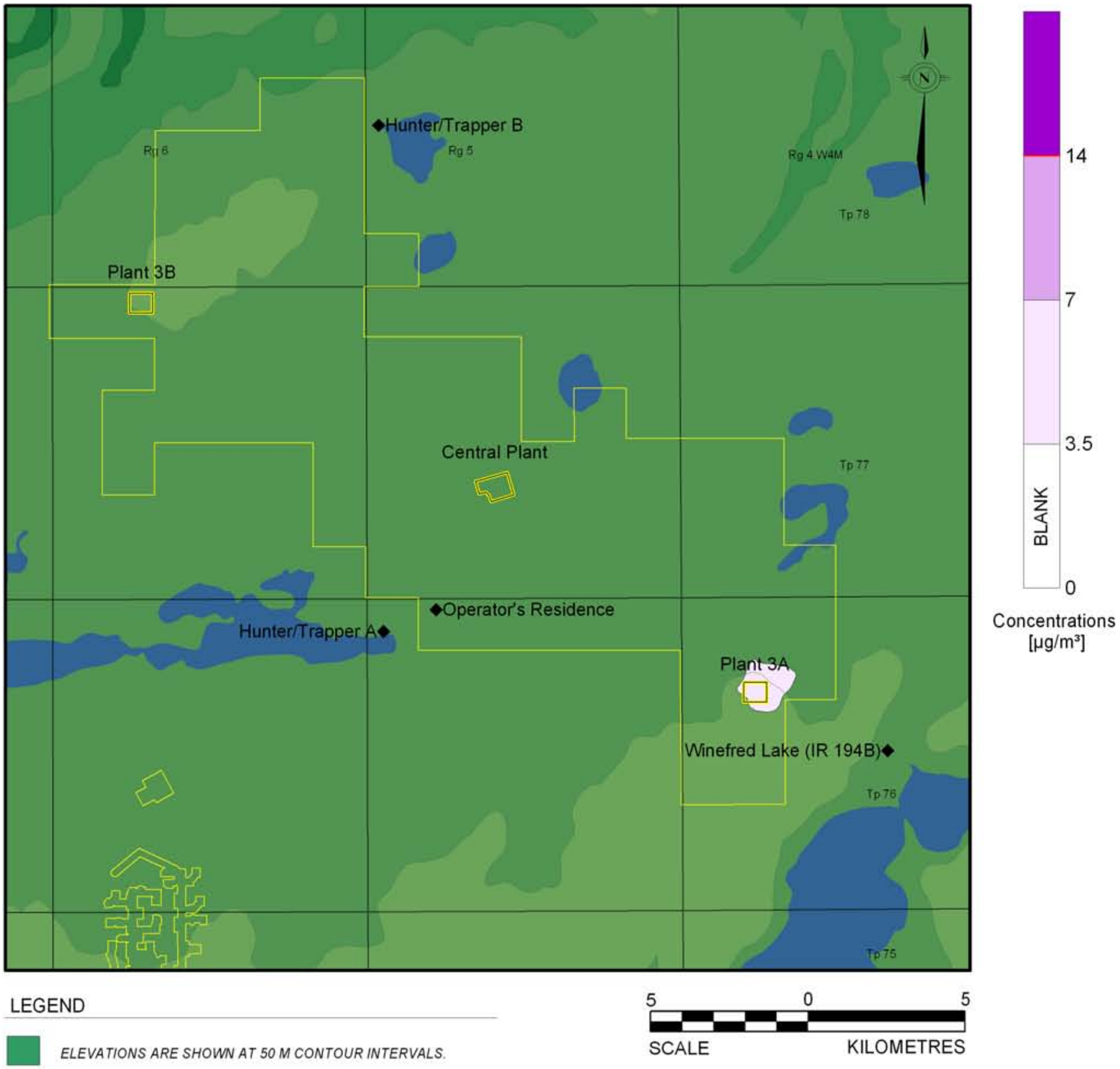

LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.*

🟩 *MEG PLANT SITES*

SCALE: AS SHOWN

REFERENCE

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DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 2
MAXIMUM 1-HOUR H_2S PREDICTIONS

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 5

The predicted SO_2 ground-level concentrations at the selected receptors for Upset Scenario 2 are presented in Table 9. Both the peak and maximum predictions are below the 1-hour SO_2 AAAQO of 450 µg/m³, with the exception of the Maximum Property Boundary. At the Maximum Property Boundary, the maximum prediction exceeds the AAAQO for 43 hours (0.5% of the year). The peak and maximum predictions at La Loche, Saskatchewan are both below the AAAQO.

Table 9 Upset Scenario 2 Predicted 1-Hour Sulphur Dioxide Concentrations at Selected Receptors

Receptor	Peak[(a)] [µg/m³]	Maximum[(b)] [µg/m³]
Conklin	9.6	6.8
Janvier/Chard (IR 194)	11.8	7.6
Winefred Lake (IR 194B)	70.4	50.3
Cabin A	43.5	24.9
Cabin B	28.4	13.1
Operator's Residence	44.4	34.9
Christina Lake Lodge	10.0	6.9
La Loche, SK	1.6	1.2
Maximum Property Boundary	1,342.9	874.4

(a) The peak concentrations represent the highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003b) when determining compliance with the AAAQOs.

(b) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003b).

The predicted H_2S ground-level concentrations at the selected receptors for Upset Scenario 2 are presented in Table 10. All the predictions, including those at La Loche, Saskatchewan, are below the 1-hour H_2S AAAQO of 14 µg/m³.

Table 10 Upset Scenario 2 Predicted 1-Hour Hydrogen Sulphide Concentrations at Selected Receptors

Receptor	Peak[(a)] [µg/m³]	Maximum[(b)] [µg/m³]
Conklin	0.1	0.0
Janvier/Chard (IR 194)	0.1	0.0
Winefred Lake (IR 194B)	0.6	0.5
Cabin A	0.2	0.1
Cabin B	0.1	0.1
Operator's Residence	0.3	0.2
Christina Lake Lodge	0.1	0.0
La Loche, SK	0.0	0.0
Maximum Property Boundary	13.4	8.7

(a) The peak concentrations represent the highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003b) when determining compliance with the AAAQOs.

(b) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003b).

4 UPSET SCENARIO 3: BLOCKED FLOW IN THE CENTRAL PLANT SITE SULPHUR RECOVERY UNIT

In Upset Scenario 3, blocked gas flow in the Central Plant Site Sulphur Recovery Unit (SRU) causes a pressure build-up. Pressure is relieved by sending the associated acid gas to the Phase 2B flare. This upset is expected to occur once per year and could last for about 10 minutes.

4.1 EMISSIONS

The acid gas from the SRU contains high concentrations of hydrogen sulphide (H_2S) and carbon dioxide (CO_2). Supplemental fuel gas would be required to raise the net heating value of the flare gas to a minimum of 12 MJ/m³. Table 11 summarizes the composition and net heating value of the flared gas.

Table 11 Upset Scenario 3 Summary

Component	Value
emission source	Phase 2B flare
flaring frequency	1 per year
flaring duration	10 minutes
flare gas flow rate [m³/min]	19.0
molecular weight	35.2
Flare Gas Composition [mole fraction]	
N_2	0.001
CO_2	0.490
H_2S	0.298
C_1	0.161
C_2	0.000
C_3	0.000
i-C_4	0.000
n-C_4	0.000
i-C_5	0.000
n-C_5	0.000
C_6	0.000
C_{7+}	0.000
H_2O	0.050
Total	**1.000**
net heating value [MJ/m³]	12.00

Table 12 provides a summary of the flaring parameters and emission rates used in the dispersion modelling. As per AENV flaring guidance (AENV 2003a), the emission rate was adjusted to account for the flaring duration.

Table 12 Upset Scenario 3 Flaring Parameters and Emission Rates

Component	Q_{max}	$Q_{max}/2$
physical height [m]	54	54
pseudo-height [m] (a)	53.063	52.510
physical diameter [m]	0.762	0.762
pseudo-diameter [m] (a)	1.703	0.490
pseudo-exit velocity [m/s] (a)	1.04	1.80
pseudo-temperature [K] (a)	2,285.5	2,285.5
SO_2 emission rate [g/s] (b)	254.4	127.2
H_2S emission rate [g/s] (c)	2.547	1.273

(a) Assumed for the purposes of dispersion modelling.

(b) It was assumed that up to 100% of the inlet sulphur to the flare (in the form of hydrogen sulphide, H_2S) can be converted to SO_2.

(c) It was assumed that up to 2% of the inlet sulphur to the flare will not be oxidized, and will be released in the form of H_2S.

4.2 MODELLING RESULTS

Table 13 presents the predicted ground-level SO_2 concentrations for Upset Scenario 3 for the maximum flow rate (Q_{max}) and 50% of the maximum flow rate ($Q_{max}/2$). For the Q_{max} flow rate, the maximum prediction (the 0.01 percentile value) exceeds the 1-hour SO_2 AAAQO of 450 µg/m³ for 91 hours or 1.0% of the year, excluding developed areas. The maximum 1-hour SO_2 predictions associated with the Q_{max} flow rate are presented in Figure 6 and the likelihoods of the maximum 1-hour SO_2 predictions exceeding the AAAQO are presented in Figure 7.

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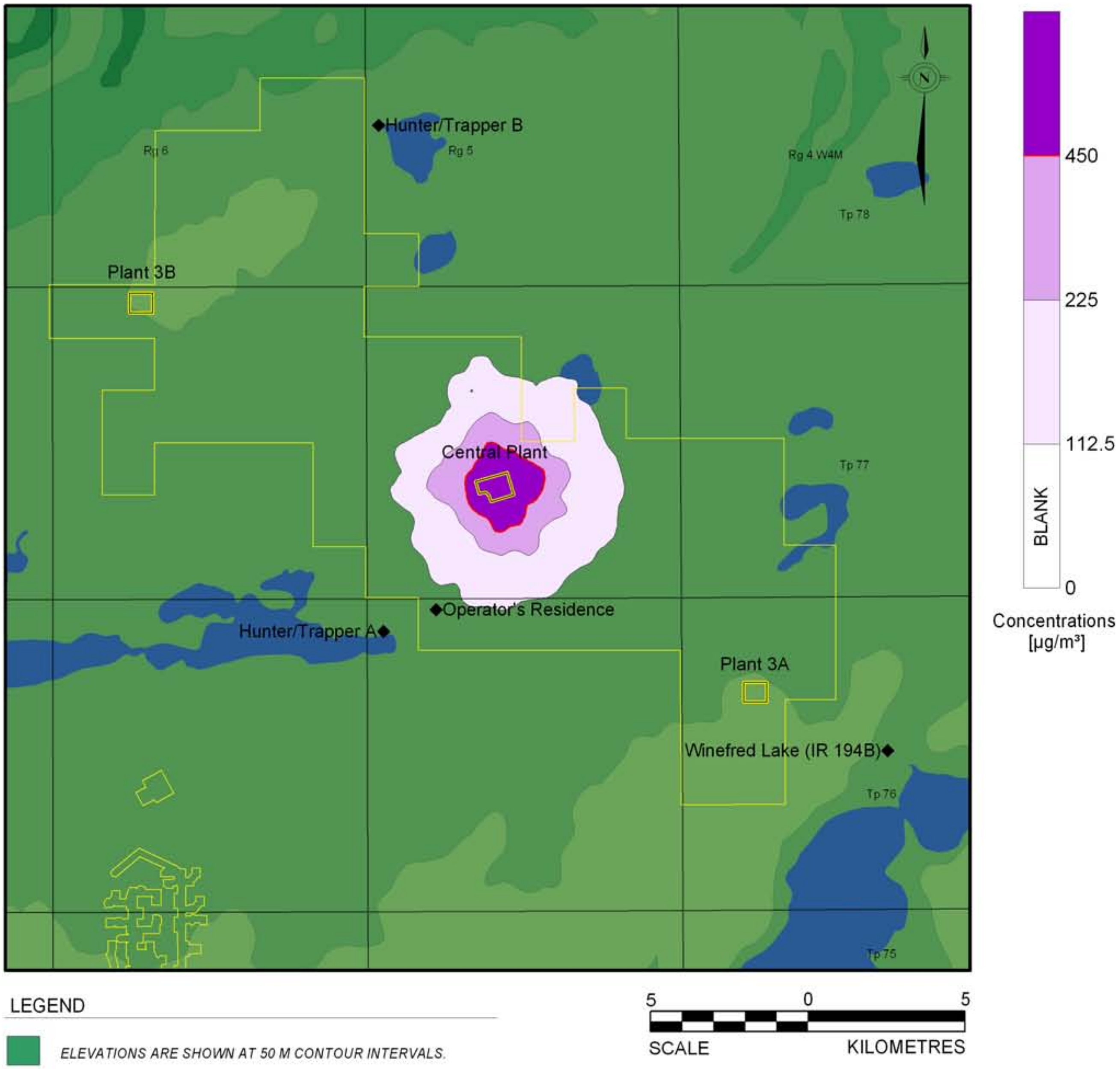


LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.*

🟩 *MEG PLANT SITES*

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.) USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

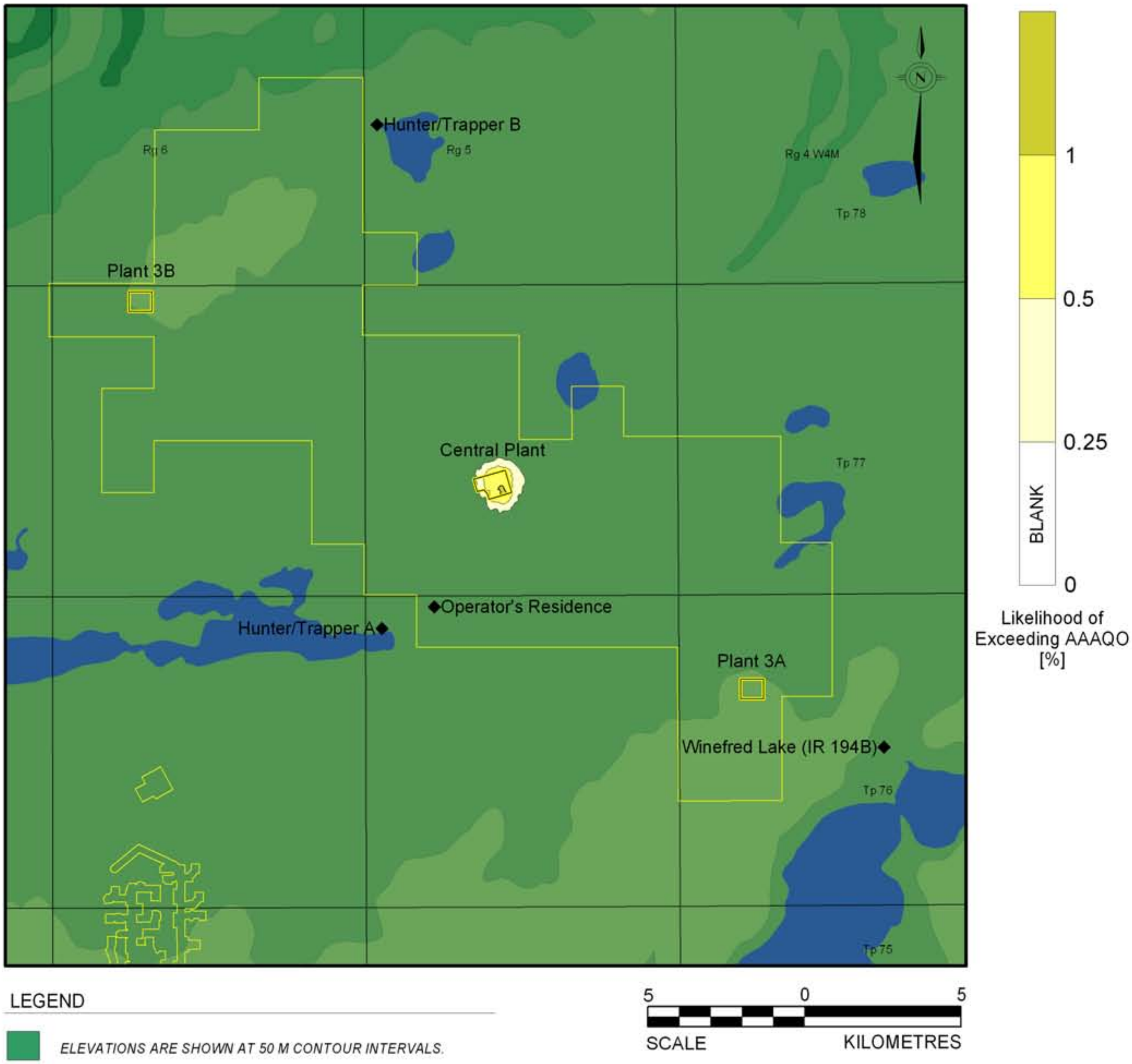
UPSET SCENARIO 3
MAXIMUM 1-HOUR SO_2 PREDICTIONS
FOR Q_{max} FLOW RATE

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 6

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/UPSET3_SO2_QMAX_%LIKELIHOOD_EXCEEDANCE.srf



LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.*

🟩 *MEG PLANT SITES*

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 3
LIKELIHOOD OF MAXIMUM 1-HOUR SO_2 PREDICTIONS EXCEEDING AAAQO FOR Q_{max} FLOW RATE

SCALE: AS SHOWN

REFERENCE

ALBERTA DIGITAL DATA OBTAINED FROM ALTALIS LTD. (SEPTEMBER 2004.) USED UNDER LICENSE. PROJECTION: TRANSVERSE MERCATOR
DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 7

Table 13 Upset Scenario 3 Predicted 1-Hour Sulphur Dioxide Concentrations

Area of Interest[a]	1-Hour Predictions [µg/m³]							
	Peak	0.001%	0.01%[b]	0.1%	1%	2%	5%	10%
Q_{max}								
predicted concentration including developed areas	3,053.4	2,951.1	2,514.5	1,412.5	527.5	371.3	233.4	137.8
predicted concentration excluding developed areas	3,053.4	2,951.1	2,185.1	1,045.2	468.7	361.7	227.6	137.8
$Q_{max}/2$								
predicted concentration including developed areas	2,262.4	2,249.5	2,133.2	1,626.2	466.5	314.1	173.6	105.8
predicted concentration excluding developed areas	1,740.5	1,688.5	1,318.5	794.2	364.9	275.0	164.6	103.1

[a] Developed areas include the Project plant sites.

[b] The maximum predicted concentration corresponds to the 0.01 percentile value.

For the $Q_{max}/2$ flow rate, the maximum prediction (the 0.01 percentile value) exceeds the AAAQO for 44 hours or 0.5% of the year, excluding developed areas. The maximum 1-hour SO_2 predictions associated with the $Q_{max}/2$ flow rate are presented in Figure 8 and the likelihoods of the maximum 1-hour SO_2 predictions exceeding the AAAQO are presented in Figure 9. The likelihoods represent the percentage of time during a modelled year that the corresponding predicted concentrations are likely to occur. These likelihood values are conservative since it is assumed that the flaring event occurs continuously all year. Realistically, this upset could occur once per year for up to 10 minutes.

Table 14 presents the predicted ground-level H_2S concentrations for Upset Scenario 3 for the Q_{max} and $Q_{max}/2$ flow rates. The maximum predicted concentrations excluding developed areas for the Q_{max} and $Q_{max}/2$ flow rates are 8.2 µg/m³ and 5.5 µg/m³, respectively, which are below the 1-hour H_2S AAAQO of 14 µg/m³. The Q_{max} and $Q_{max}/2$ flow rate maximum 1-hour H_2S predictions for Upset Scenario 3 are presented in Figures 10 and 11, respectively.

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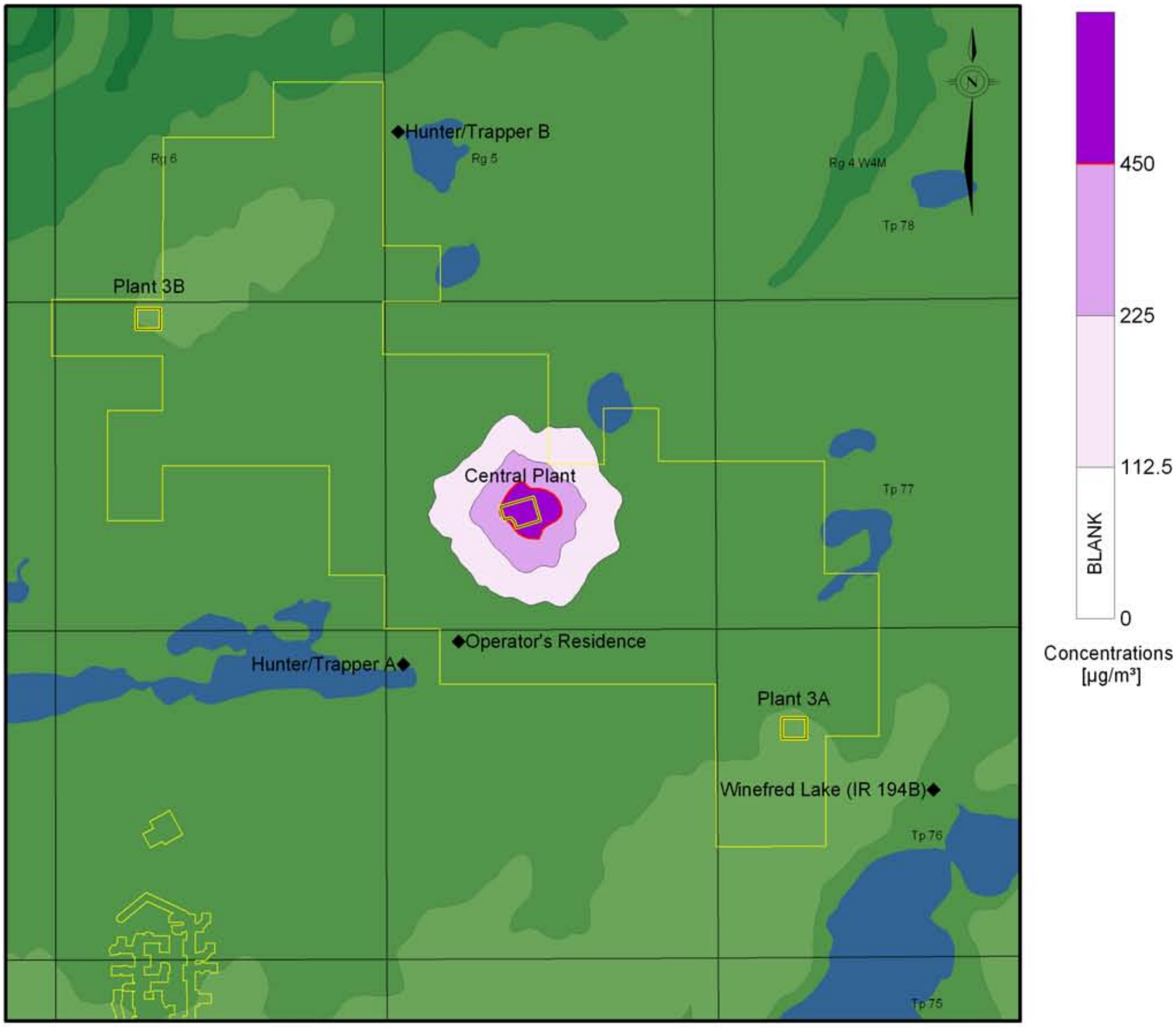

LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

🟩 *MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.*

🟩 *MEG PLANT SITES*

5 0 5

SCALE KILOMETRES

SCALE: AS SHOWN

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DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 12

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 3
MAXIMUM 1-HOUR SO_2 PREDICTIONS
FOR Q_{max} /2 FLOW RATE

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 8

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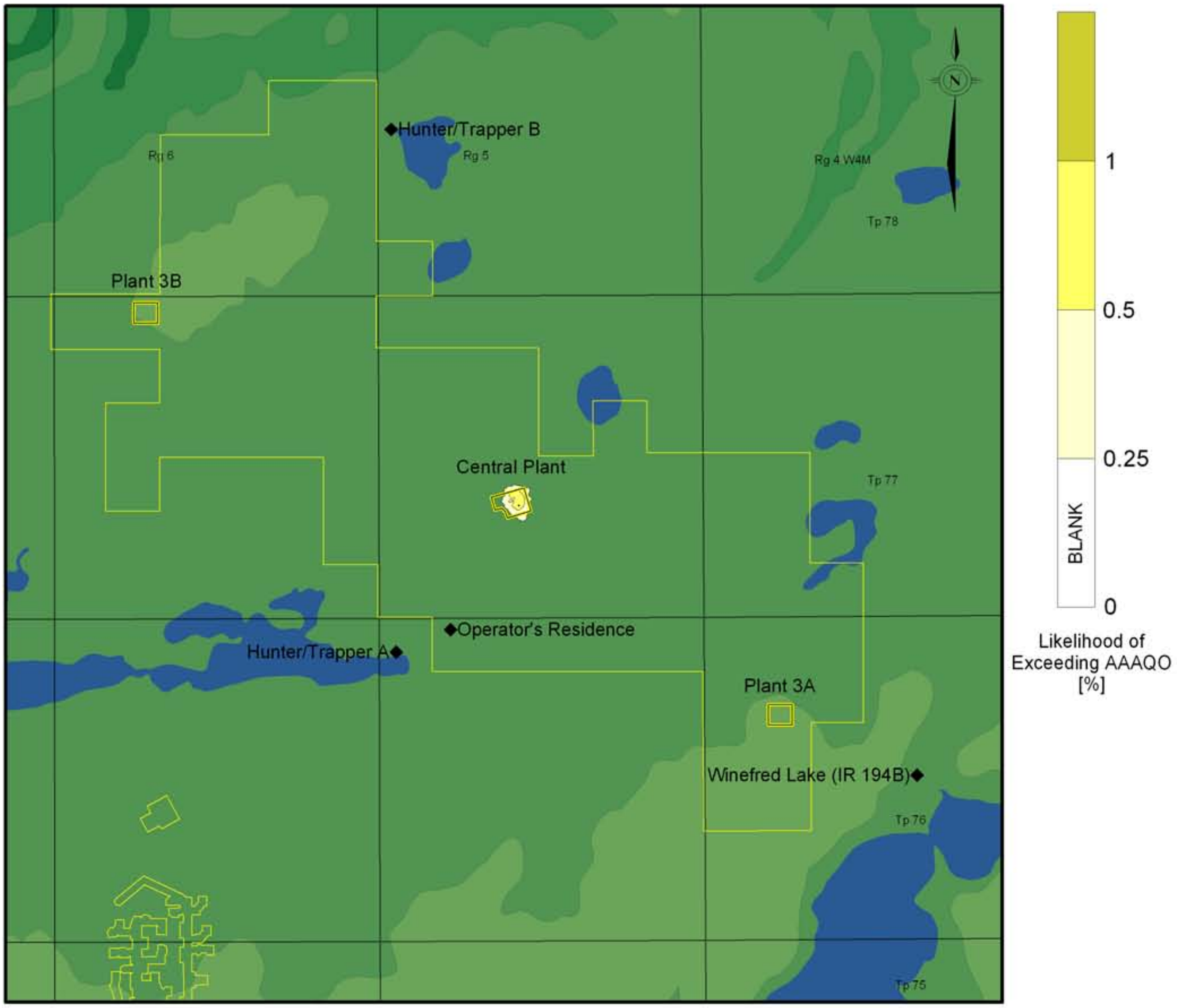

5 0 5

SCALE KILOMETRES

LEGEND

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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

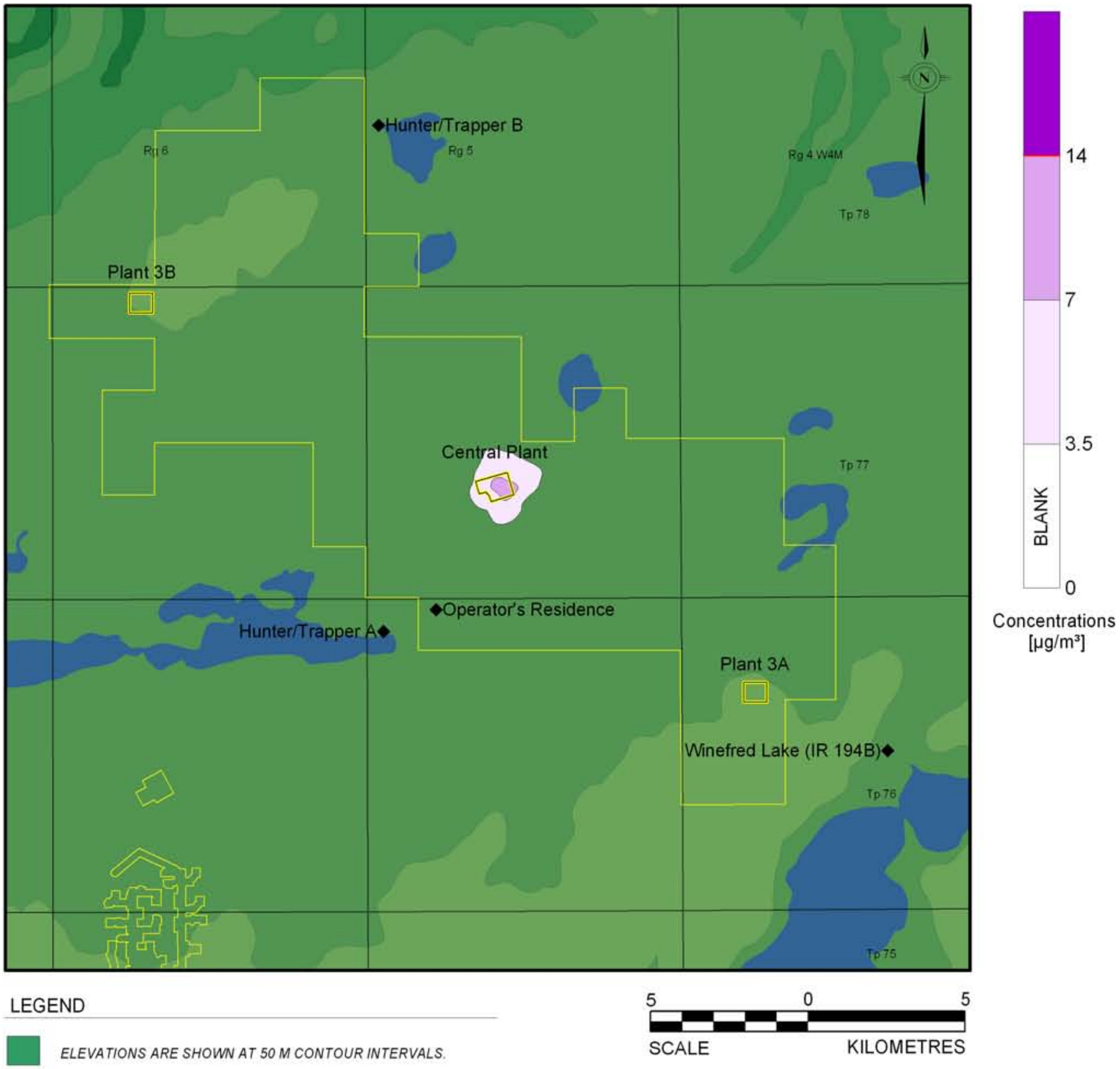
UPSET SCENARIO 3
LIKELIHOOD OF MAXIMUM 1-HOUR SO_2 PREDICTIONS
EXCEEDING AAAQO FOR Q_{max} /2 FLOW RATE

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 9

R:/ACTIVE/_2007/1346/07-1346-0009 MEG CHRISTINA LAKE REGIONAL EXPANSION/8000 AIR/8070 EIA REPORTING/FIGURES/UPSET3_H2S_QMAX_h.srf



LEGEND

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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 3
MAXIMUM 1-HOUR H_2S PREDICTIONS
FOR Q_{max} FLOW RATE

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
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REVIEW	IGG	10/04/08

FIGURE: 10

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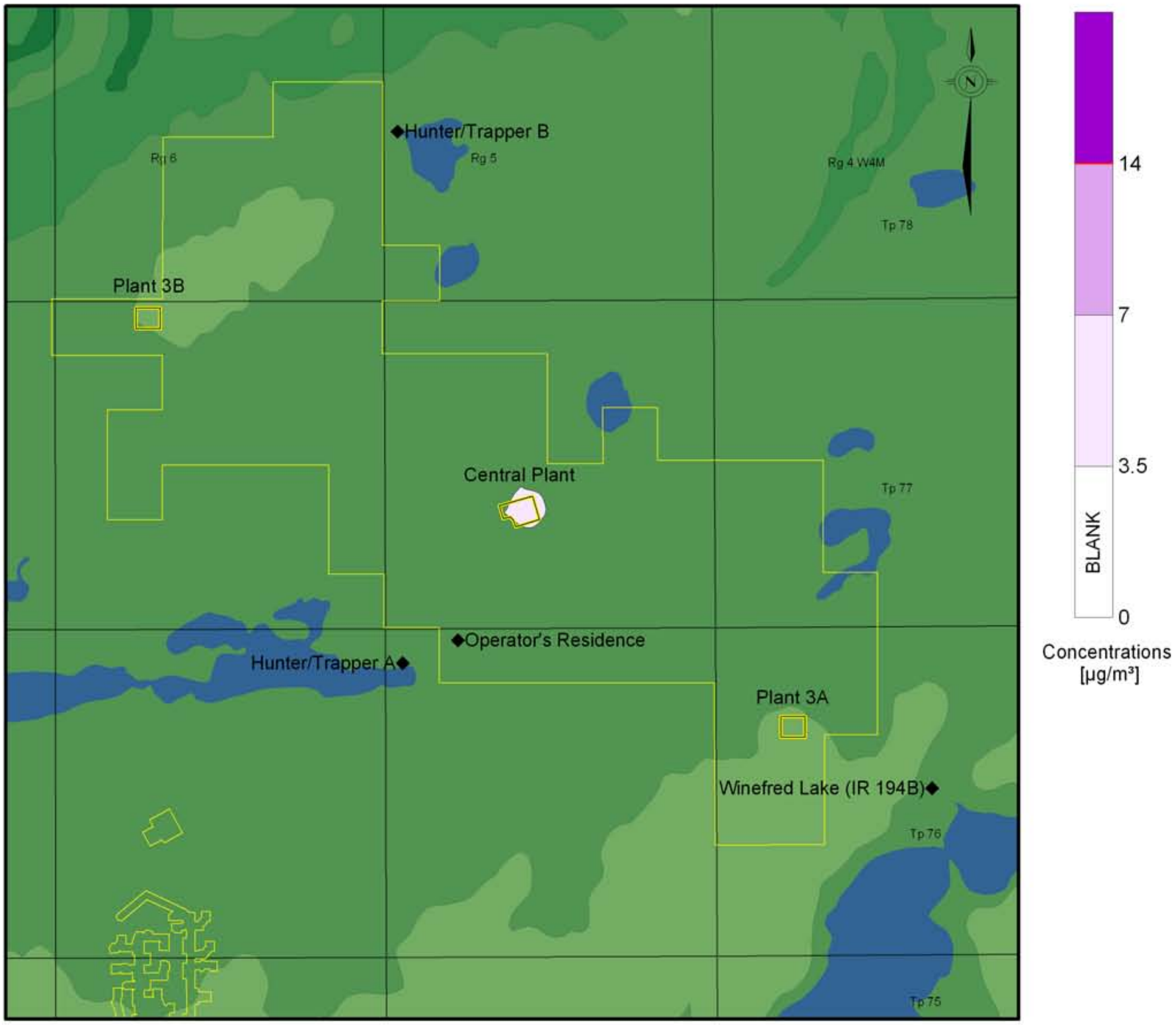

LEGEND

🟩 *ELEVATIONS ARE SHOWN AT 50 M CONTOUR INTERVALS.*

MEG LEASE BOUNDARY AND OTHER PROJECT BOUNDARIES IN THE LSA.

MEG PLANT SITES

5 0 5
SCALE KILOMETRES

SCALE: AS SHOWN

REFERENCE

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PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

UPSET SCENARIO 3
MAXIMUM 1-HOUR H_2S PREDICTIONS
FOR Q_{max}/2 FLOW RATE

MEG ENERGY CORP.

DESIGN	MS	20/02/08
AIR	GH	25/02/08
CHECK	MS	27/02/08
REVIEW	IGG	10/04/08

FIGURE: 11

Table 14 Upset Scenario 3 Predicted 1-Hour Hydrogen Sulphide Concentrations

Area of Interest[a]	Peak Concentration[b] [µg/m³]	Maximum Concentration[c] [µg/m³]
Q_{max}		
predicted concentration including developed areas	28.4	11.6
predicted concentration excluding developed areas	24.7	8.2
$Q_{max}/2$		
predicted concentration including developed areas	22.6	16.8
predicted concentration excluding developed areas	11.7	5.5

(a) Developed areas include the Project plant sites.

(b) The peak concentrations represent the highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003b) when determining compliance with the AAAQOs.

(c) The maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta Air Quality Model Guideline (AENV 2003b).

The predicted SO_2 ground-level concentrations for the Q_{max} and $Q_{max}/2$ flow rates at the selected receptors for Upset Scenario 3 are presented in Table 15. All SO_2 predictions are below the 1-hour SO_2 AAAQO of 450 µg/m³, with the exception of the Maximum Property Boundary value. At this receptor, the maximum prediction exceeds the AAAQO for 91 hours (1.0%) of the year for the Q_{max} flow rate. For the $Q_{max}/2$ flow rate the AAAQO is predicted to be exceeded for 44 hours (i.e., 0.5%) per year. The peak and maximum predictions at La Loche, Saskatchewan are below the AAAQO.

Table 15 Upset Scenario 3 Predicted 1-Hour Sulphur Dioxide Concentrations at Selected Receptors

Receptor	Q_{max}		$Q_{max}/2$	
	Peak[a] [µg/m³]	Maximum[b] [µg/m³]	Peak[a] [µg/m³]	Maximum[b] [µg/m³]
Conklin	14.7	11.5	11.0	8.2
Janvier/Chard (IR 194)	19.7	10.0	13.2	7.6
Winefred Lake (IR 194B)	35.6	24.3	24.3	16.6
Cabin A	88.0	65.6	67.6	48.1
Cabin B	47.6	27.8	41.6	19.3
Operator's Residence	117.8	82.5	89.2	63.6
Christina Lake Lodge	22.6	13.1	16.1	9.9
La Loche, SK	2.3	1.7	1.6	1.2
Maximum Property Boundary	3,041.8	1,063.5	1,736.9	812.5

(a) The peak concentrations represent the highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003b) when determining compliance with the AAAQOs.

(b) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003b).

The predicted H_2S ground-level concentrations at the selected receptors for Upset Scenario 3 are presented in Table 16. All maximum H_2S predictions are below the 1-hour H_2S AAAQO of 14 μg/m³. The peak and maximum predictions at La Loche, Saskatchewan are below the AAAQO.

Table 16 Upset Scenario 3 Predicted 1-Hour Hydrogen Sulphide Concentrations at Selected Receptors

Receptor	**Q_{max}**		**$Q_{max}/2$**	
	Peak[(a)] [μg/m³]	**Maximum[(b)] [μg/m³]**	**Peak[(a)] [μg/m³]**	**Maximum[(b)] [μg/m³]**
Conklin	0.1	0.1	0.1	0.0
Janvier/Chard (IR 194)	0.1	0.1	0.1	0.0
Winefred Lake (IR 194B)	0.2	0.2	0.1	0.1
Cabin A	0.6	0.4	0.5	0.2
Cabin B	0.3	0.2	0.3	0.1
Operator's Residence	0.8	0.6	0.6	0.4
Christina Lake Lodge	0.1	0.1	0.1	0.0
La Loche, SK	0.0	0.0	0.0	0.0
Maximum Property Boundary	24.7	8.2	11.7	5.5

(a) The peak concentrations represent the highest 1-hour predictions from the CALPUFF model. However, the eight highest 1-hour predictions should be excluded (AENV 2003b) when determining compliance with the AAAQOs.

(b) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2003b).

5 REFERENCES

AENV (Alberta Environment). 2003a. Emergency/Process Upset Flaring Management: Modelling Guidance. Prepared by A. Idriss, Science and Standards Branch. Edmonton, AB.

AENV. 2003b. Air Quality Model Guidelines. Prepared by the Science and Technology Branch, Environmental Services Division Alberta Environment. Edmonton, AB.

EUB (Alberta Energy and Utilities). 2006. Directive 060: Upstream Petroleum Industry Flaring, Incinerating and Venting.

5.1 INTERNET SOURCES

ERCB (Alberta Energy Resources Conservation Board). 2007. Directive 060 Spreadsheets: EUBflare.xls. Accessed December 5, 2007. Avaliable at http://www.ercb.ca/portal/server.pt/gateway/PTARGS_0_240_2486602_0_0_18/.

APPENDIX 3-V

NOISE MODELLING METHODS

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WHICH CAN BE FOUND AT THE BACK OF THIS VOLUME.

APPENDIX 3-VI

SCREENING LEVEL WILDLIFE RISK ASSESSMENT

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The primary objective of the Screening-Level Wildlife Risk Assessment (SLWRA) is to describe the nature and significance of potential adverse population-level effects to wildlife that might be associated with emissions from the proposed MEG Energy Corp. (MEG) Christina Lake Regional Project (CLRP) – Phase 3 (the Project). A population-level effect is defined as a decline or change in abundance or distribution of the wildlife population over time, such that natural recruitment is unable to re-establish the population to its original level (Suter II et al. 2000). The SLWRA examined both short-term (acute) and long-term (chronic) risks attributable to the Project combined with existing or approved developments, as well as with other proposed or planned regional developments for the region. To assess potential risks to wildlife, predicted exposures will be compared with Toxicity Reference Values (TRVs) protective of the health of wildlife populations.

2 SCOPE OF ASSESSMENT

The key features influencing the scope of the SLWRA are outlined below and discussed in detail in the sections following:

- identification of the Terms of Reference (TOR) (Alberta Environment (AENV) 2008) issued by AENV that will be addressed as part of the SLWRA; and
- determination of the concerns expressed by stakeholders regarding potential health risks to wildlife populations associated with the Project.

2.1 TERMS OF REFERENCE

This assessment was completed to meet the relevant TOR (AENV 2008) for the Project (Table 1) which state the following:

Table 1 Terms of Reference Concordance Table

TOR Section	Environmental Assessment or Topic	Location TOR Addressed
4.8.2 Wildlife Impact Assessment	i) potential effects on wildlife as a result of changes to air, water, including both acute and chronic effects on animal health, and	c) Volume 3, Appendix 3-VI

2.2 SELECTION OF MEASUREMENT AND ASSESSMENT ENDPOINTS

To focus the SLWRA on issues of primary concern, specific assessment and measurement endpoints were selected. An assessment endpoint is defined as “the characteristic of the ecological system that is the focus of the risk assessment” and that needs to be protected. A measurement endpoint is defined as “the effect on an ecological component that can be measured and described in some quantitative fashion” (Canadian Council of Ministers of the Environment (CCME) 1996; Gaudet et al. 1994).

For the current SLWRA, the assessment endpoints were defined as “potential effects on wildlife populations”. The associated measurement endpoints were defined as follows:

- ratios between predicted chemical concentrations in air and corresponding wildlife inhalation toxicity data; and
- ratios between predicted soil chemical concentrations and corresponding soil quality guidelines or criteria intended to be protective of all terrestrial ecological receptors.

3 ASSESSMENT METHODS

The current assessment is a Screening-Level Ecological Risk Assessment (SLERA) based on a tiered framework developed by Environment Canada (Gaudet et al. 1994) and the Canadian CCME (1996) for contaminated sites. The three tiers of ecological risk assessments are listed below.

Screening-Level Ecological Risk Assessment (SLERA)

A SLERA is an assessment of the potential environmental risk to specific ecological receptors that have been determined to be of major importance. These are called Valued Ecosystem Components (VECs). A SLERA is based primarily on data from literature reviews and from previous or preliminary studies in the Project area. It should provide sufficient information to determine whether mitigation is or is not required, or it may provide a basis for determining the required level of Ecological Risk Assessment (ERA) that is required and for focusing future, more detailed investigations of potential effects.

Preliminary Quantitative Risk Assessment (PQRA)

A PQRA uses a combination of literature information and site-specific data collected specifically for ERA purposes to determine preliminary quantitative risk estimates for specified VECs exposed to the substances of concern. It focuses on filling significant data gaps identified at the screening level. The methods used are more complex than for a screening-level assessment and are directed at producing quantitative assessments of risk.

Detailed Quantitative Risk Assessment (DQRA)

A DQRA uses more extensive and complicated field assessments and modelling of contaminant movement, exposure pathways, ecosystem characterization and toxicity assessment to attempt to fill significant data gaps and uncertainties already identified, and to quantitatively assess risk. Bioassays are likely to be important tools in assessing toxicity at this assessment level.

Each tier is sequentially more detailed, with assessment characteristics ranging from a simple, qualitative and literature-based approach for the SLERA, to more complex, quantitative, predictive and field-based approaches for the DQRA (CCME 1996). While each of the tiers differs in complexity, the components outlined in Figure 1 are identical for each of the three tiers.

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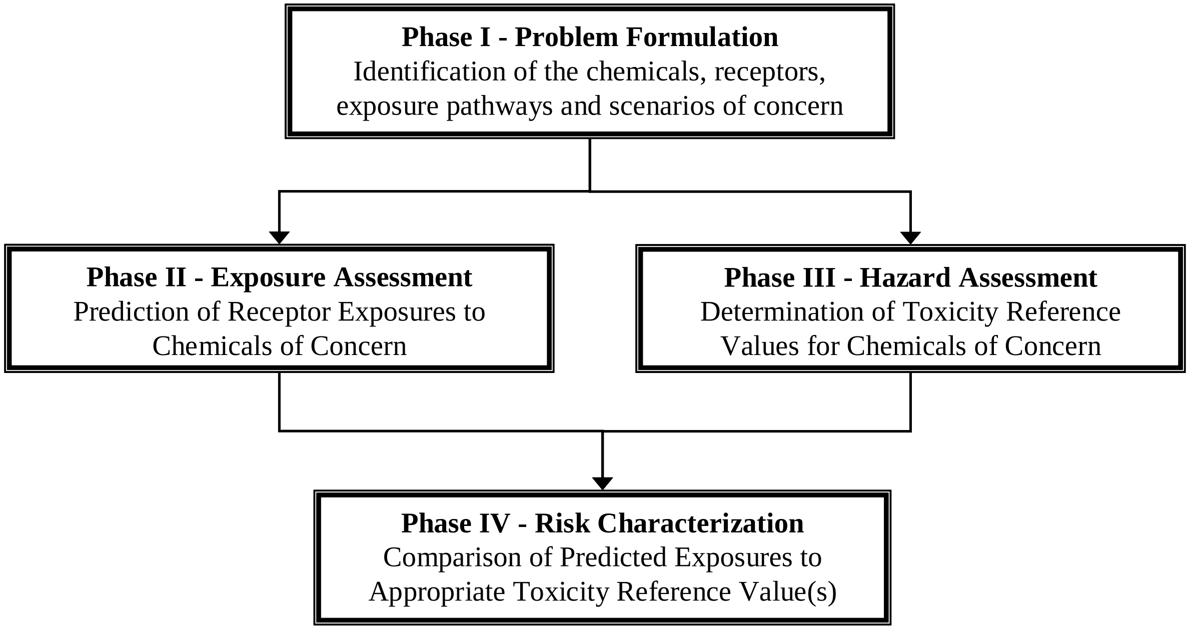

Phase I - Problem Formulation
Identification of the chemicals, receptors, exposure pathways and scenarios of concern

Phase II - Exposure Assessment
Prediction of Receptor Exposures to Chemicals of Concern

Phase III - Hazard Assessment
Determination of Toxicity Reference Values for Chemicals of Concern

Phase IV - Risk Characterization
Comparison of Predicted Exposures to Appropriate Toxicity Reference Value(s)

PROJECT

CHRISTINA LAKE REGIONAL PROJECT - PHASE 3

TITLE

ECOLOGICAL RISK ASSESSMENT METHODOLOGY

MEG ENERGY CORP.

PROJ	07.1346.0009.8810		FILE No. Eco_Risk_Assessment
DESIGN	BK	07/03/08	SCALE AS SHOWN REV. 0
CADD	TRE	07/03/08	**FIGURE: 1**
CHECK	BK	01/04/08	
REVIEW	IGG	01/04/08	

The use of a tiered approach focuses the assessment on the most critical issues in a time and cost effective manner. The scope for a SLWRA in the initial tier (i.e., SLERA) employs highly conservative assumptions and readily available data. By using conservative assumptions regarding both chemical exposure and chemical toxicity in the SLWRA, a high degree of confidence can be placed in the validity of the findings. Thus, if no risks are identified in the screening-level SLWRA, further study is considered unnecessary.

However, in situations where a screening-level assessment indicates the potential for an unacceptable risk to wildlife populations, or where insufficient information exists to complete this level of assessment, further data collection may be required to complete the study (i.e., a higher tier of risk assessment).

3.1 ASSESSMENT CASES

In accordance with the TOR, potential health risks were assessed for the following three assessment cases:

- Existing and Approved Case (EAC): includes potential health risks associated with existing developments and those that have been approved but are not yet operational.
- Project Case: includes potential health risks associated with existing and approved developments (EAC) as well as the Project.
- Planned Development Case (PDC): includes potential health risks associated with all of the developments incorporated in the Project Case as well as those developments that were publicly disclosed six months prior to the submission of the Environmental Impact Assessment (EIA).

3.2 TEMPORAL CONSIDERATIONS

Construction of the Project is proposed to occur in two phases. Phase 3A is anticipated to begin construction in 2010, with initial steam injection in 2012. Phase 3B is anticipated to begin construction in 2012, with initial steam injection in 2014. The operational life of each plant is expected to be 25 years. Total production from the two new plants will produce an incremental 150,000 bpd of bitumen. It is anticipated that reclamation of the Project will be complete by 2044.

The SLWRA assessed potential short-term (acute) and long-term (chronic) health risks to wildlife associated with the Chemicals of Potential Concern (COPCs) emitted or released from the Project. The two exposure durations used can be described as follows:

- acute: exposure extends over a period covering seconds to hours to a number of days; and
- chronic: exposure occurs continuously or regularly over extended periods, lasting for periods of months through years, and possibly extending over an entire lifetime.

To evaluate potential cumulative effects in the region, the SLWRA conservatively assumed that the chemical emissions or releases attributable to the Project would occur simultaneously with emissions from all other sources.

3.3 SPATIAL CONSIDERATIONS

The SLWRA for the Project focused on potential health risks to wildlife populations in the:

- Regional Study Area (RSA): The area over which potential health risks were assessed. The RSA for the SLWRA corresponds to the Air Quality RSA (Volume 3, Section 1, Figure 1.2-1) which encompasses a 110 km by 120 km area.
- Local Study Area (LSA): The area in the immediate vicinity of the Project where the greatest influence on air quality is expected to occur. The LSA for the SLWRA corresponds to the Air Quality LSA (Volume 3, Section 1, Figure 1.2-1) which is defined by an area of approximately 30 km by 30 km, encompassing the Project area.

3.4 ASSESSMENT METHODS

As defined earlier, the current SLWRA is a screening-level ecological risk assessment to reflect the focus on wildlife within the ecosystem, and not the ecosystem as a whole. The four steps of risk assessment followed in this study, as outlined in Figure 1, are:

- Problem Formulation: identification of the COPCs associated with the Project emissions, characterization of wildlife receptors potentially “at risk” and determination of the relevant exposure pathways.
- Exposure Assessment: quantification of the potential amount or dose of each COPC received by wildlife receptors through all relevant exposure pathways.

- Toxicity Assessment: determination of safe levels of exposure or TRVs for wildlife populations following exposure for a prescribed period (i.e., acute or chronic).
- Risk Characterization: comparison of estimated exposures (determined in the exposure assessment) with maximum safe dose levels (established in the toxicity assessment) to identify potential health risks for the different assessment cases, as well as discussion of sources of uncertainty and how these were addressed in the risk assessment.

Each of these steps is described in detail in the following sections.

3.4.1 Problem Formulation

The purpose of the problem formulation is to collect information to further focus the SLWRA, as described in detail below:

- Identification of the Chemicals of Potential Concern (COPCs) – identifying COPCs emitted or released from the Project that might contribute to potential wildlife health risks.
- Characterization of wildlife receptors potentially at risk – identifying wildlife that might be exposed to emissions from the Project, with special consideration given to sensitive or at risk wildlife receptors.
- Identification of relevant exposure pathways – ensures that applicable exposure pathways are identified, with consideration given to the physical-chemical properties of the COPCs, their fate and transport characteristics and their tendency to persist and concentrate in the environment.

3.4.1.1 Identifying Chemicals of Potential Concern

The COPCs for the Project were identified through:

- development of an inventory of chemicals that could be emitted or released by the Project;
- determination of whether or not sufficient toxicological information is available to assess potential health risks; and
- selection of chemical surrogates to represent any of the compounds for which no suitable exposure limits were available.

The COPCs identified for inclusion in the SLWRA closely matched those selected for the human health risk assessment (Volume 3, Section 3.4.4.1).

Polycyclic Aromatic Hydrocarbons (PAHs) were evaluated individually (when possible) and as part of either a High Molecular Weight (HMW) PAH group or a Low Molecular Weight (LMW) PAH group. Given that the HMW PAH group and the aromatic C_{17}-C_{34} group contain the same individual constituents (i.e., PAH groups 1-3 and pyrenes and substituted pyrenes) and the HMW PAH group has a more conservative soil quality guideline, the aromatic C_{17}-C_{34} group was not evaluated in the SLWRA. Table 2 lists the COPCs selected for inclusion in the SLWRA.

Table 2 Identification of Chemicals of Potential Concern

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Aliphatic C_2-C_8 group	1,1,3-Trimethylcyclopentane, 1,1-dimethylcyclohexane, 1,1-dimethylcyclopentane, 1,2,3-trimethylcyclopentene, 1,2,4-trimethylcyclopentane, 1,2-dimethylcyclohexane, 1,2-dimethylcyclopentane, 1,3-dimethyl-2-(1-methylene)cyclopentene, 1,3-dimethylcyclopentane, 1,4-dimethylcyclohexane, 1,5-dimethylcyclopentene, 1-ethyl-1-methylcyclopropane, 1-hexene, 1-methyl-1-(2-methylene)cyclopentane, 1-methyl-2-methylene cyclopentane, 1-methyl-4-(1-methylene)cyclohexane, 1-methyl-4-(1-methylethyl)cyclohexane, 1-methyl-4-(methylene)cyclohexane, 1-methyl-4-(methylene)cyclohexene, 1-propyne, 2,2,3-trimethylbutane, 2,2,3-trimethylpentane, 2,2,4-trimethylpentane, 2,2-dimethylbutane, 2,2-dimethylpropane, 2,3,4-trimethylpentane, 2,3-dimethylbutane, 2,3-dimethylhexane, 2,3-dimethylpentane, 2,4-dimethyl-1-pentene, 2,4-dimethylhexane, 2,4-dimethylpentane, 2,5-diethylthiophene, 2,5-dimethyl-1,3-hexadiene, 2,5-dimethylhexane, 2,5-dimethylthiophene, 2-ethyl-1-hexanol, 2-ethyl-2-hexene, 2-ethyl-3-methylcyclopentene, 2-hexene, 2-methyl-1-butene, 2-methyl-1-pentene + 1-hexene, 2-methyl-2-pentene, 2-methyl-3-pentene, 2-methyl-4-pentene, 2-methylbutane, 2-methylbycycloheptane, 2-methylcyclopentane, 2-methylheptane, 2-methylhexane, 2-methylpentane, 2-methylpentane + cyclopentane, 2-octene, 2-propanol, 3,3-dimethyl-1-butene, 3,3-dimethylpentane, 3,4-dimethyl-1-pentene, 3-ethylhexane, 3-methyl-1,3-pentadiene, 3-methyl-1,3-pentadiene(e), 3-methyl-1,3-pentadiene(z), 3-methyl-1-butene, 3-methyl-1-hexene, 3-methyl-2-hexene, 3-methyl-2-pentene, 3-methylcyclopentene, 3-methylene pentane + 2,3-dimethybutane, 3-methylheptane, 3-methylhexane, 3-methylpentane, 4,4-dimethylcyclopentene, 4-methyl-1-(1-methylene)cyclohexene, 4-methyl-3-heptene, 4-methylcyclohexene, 4-methylheptane, 5-methyl-1,4-hexadiene, acetylene + ethane, butane, butene, c-1,2-dimethylcyclohexane, c-1,3-dimethylcyclohexane, c-1,3-dimethylcyclopentane, c-1-butyl-2-methylcyclopropane, cis-2-butene, cis-2-hexene, cyclohexane, cyclohexene, cyclooctane, cyclopentane, ethane, ethylcyclopentane, ethylene, ethyne, heptane, hexane, i-butane	n/a

Table 2 Identification of Chemicals of Potential Concern (continued)

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Aliphatic C_9-C_{16} group	1,1,2,3-Tetramethylcyclohexane, 1,1,2,3-tetramethylcyclopentane, 1,1,3,4-tetramethylcyclopentane, 1,1,3,5-tetramethylcyclohexane, 1,1,3-trimethylcyclohexane, 1,1,4-trimethylcyclohexane, 1,2-diethyl-1-methyl-cyclohexane, 1,3,5-trimethyl-2-octadecylcyclohexane, 1-ethyl-2,3-dimethylcyclohexane, 1-ethyl-2,4-dimethylcyclohexane, 1-ethyl-2-propyl cyclohexane, 1-pentyl-2-propylcyclopentane, 2,2,5-trimethylhexane, 2,2,7-trimethyl-3-octyne, 2,2-dimethyl-3-decene, 2,2-dimethyl-3-octyne, 2,3,4-trimethylhexane, 2,3-dimethyloctane, 2,4-diethyl-1-methylcyclohexane, 2,5,5-trimethyl-1,6-heptadiene, 2,5,5-trimethyl-1-hexene, 2,6,10-trimethyltridecane, 2,6-dimethyl-2-octene, 2,6-dimethyl-4-octene, 2,6-dimethylheptane, 2,4-methyloctane, 2-methyl-4,5-nonadiene, 2-methyloctyne, 3,3,4-trimethylhexane, 3,3,4-trimethylcyclohexene, 3,3,8-trimethyldecane, 3,7,7-trimethyl bicycloheptane, 3,7-dimethyl-1-octene, 3-dodecene, 3-ethyl-2-methyl-1,3-hexadiene, 3-ethyl-2-methyl-2-heptene, 3-ethyl-3-octene, 3-methyloctane, 4,8-dimethyl-1,7-nonadiene, 4-ethyloctane, 4-methyl-2,7-octadiene, 4-methyloctane, 5-eicosyne, 7-methyl-5-undecene, amorphane, bicyclononane, butylidenecyclohexane, decane, decylcyclohexane, ethylidenecycloheptane, farnesane, heptylcyclohexane, hexadecane, hexylcyclohexane, isocamphase, n-decane, n-dodecane, n-hexadecane, n-nonane, nonane, nonylcyclohexane, norfarnesane, n-pentadecane, n-tetradecane, n-tridecane, octahydropentalene, octylcyclohexane, pentylcyclohexane, tetradecane, tridecane	n/a
Aliphatic C_{17}-C_{34} group	8b,13a-Dimethyl-14b-n-butylpodocarpane, dodecylcyclohexane, n-eicosane, n-heneicosane, n-heptadecane, n-nonadecane, n-octadecane, norpristane, pentadecylcyclohexane, phytane, pristane, tetradecylcyclohexane, tridecylcyclohexane, undecylcyclohexane	n/a
Aromatic C_9-C_{16} group	Acenaphthenes/acenaphthylenes: Acenaphthene, acenaphthylene, acephenanthrylene Anthrancenes/phenanthrenes and substituted:1-Methylphenanthrene, 2-methylanthracene, 2-methylphenanthrene, 3-methylphenanthrene, 4-methylphenanthrene, 9-methylphenanthrene, anthracene, phenanthrene, retene Aromatic C_9-C_{16}: 2,3-Dimethylbenzaldehyde, 2-ethyl-toluene, 3-ethyl-toluene, 4-ethyl-toluene, cumene, fluorenone, indanone, i-isopropylbenzene, methylpropylbenzene, n-ethyltoluene, n-butylbenzene, n-decylbenzene, n-hexylbenzene, n-octylbenzene, n-propylbenzene, p-cymene, p-ethyltoluene, propylbenzene, xanthone Fluorenes/fluoranthenes and substituted: 2-Methylfluorene, 3-methyldibenzothiophene, 4-methyldibenzothiophene, dibenzothiophene, fluoranthene, fluorene Naphthalenes and substituted: 1-Methylnaphthalene, 2-methylnaphthalene, naphthalene, indole Trimethylbenzenes: 1,2,3-Trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene	n/a

Table 2 Identification of Chemicals of Potential Concern (continued)

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Arsenic	Arsenic	n/a
Barium	Barium	n/a
Benzene	Benzene	n/a
Beryllium	Beryllium	n/a
Cadmium	Cadmium	n/a
Carbon disulphide group	Carbon disulphide, carbonyl sulphide	Carbon disulphide
Carbon Monoxide	Carbon Monoxide	n/a
Chromium	Chromium	n/a
Cobalt	Cobalt	n/a
Copper	Copper	n/a
Ethylbenzene	Ethylbenzene	n/a
Ethylene	Ethylene	n/a
Formaldehyde	Formaldehyde	n/a
Hexane group	1-Hexene, 2,3-dimethylhexane, 2,4-dimethylhexane, 2,5-dimethyl-1,3-hexadiene, 2,5-dimethylhexane, 2-ethyl-1-hexene, 2-hexene, 2-methylhexane, 3-ethylhexane, 3-methyl-1-butene, 3-methyl-1-hexene, 3-methyl-2-hexene, 3-methylhexane, cis-2-hexene, hexane, n-hexane, trans-2-hexene	Hexane
High Molecular Weight (HMW) PAH group	PAH group 1: Benzo(a)pyrene, benzo(e)pyrene, dibenz(a,h)anthracene, 1-nitropyrene PAH group 2: 3-Methylcholanthrene, 7,12-dimethylbenz(a)anthracene, benz(a)anthracene, benzo(a)fluorene, benzo(b)fluoranthene, benzo(g,h,i)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, cyclopenta(c,d)pyrene, indeno(1,2,3-cd)fluoranthene, indeno(1,2,3-cd)pyrene, indeno(1,2,3-w)pyrene PAH group 3: Carbazole, chrysene, coronene, perylene, benzo(g,h,i)perylene, benzo(g,h,i)perylene Pyrenes and substituted: 2-Methylpyrene, picene, pyrene	n/a
Hydrogen sulphide	Hydrogen sulphide	n/a
Lead	Lead	n/a
Low Molecular Weight (LMW) PAH group	Acenaphthenes/acenaphthylenes: Acenaphthene, acenaphthylene, acephenanthrylene Anthrancenes/phenanthrenes and substituted:1-Methylphenanthrene, 2-methylanthracene, 2-methylphenanthrene, 3-methylphenanthrene, 4-methylphenanthrene, 9-methylphenanthrene, anthracene, phenanthrene, retene Fluorenes/fluoranthenes and substituted: 2-Methylfluorene, 3-methyldibenzothiophene, 4-methyldibenzothiophene, dibenzothiophene, fluoranthene, fluorene Naphthalenes and substituted: 1-Methylnaphthalene, 2-methylnaphthalene, naphthalene, indole	
Manganese	Manganese	n/a
Mercury	Mercury	n/a

Table 2 Identification of Chemicals of Potential Concern (continued)

Chemicals of Potential Concern	Chemical Constituent(s)	Surrogate Chemical (if applicable)
Methyl ethyl ketone group	3-Buten-2-one, acetone, butanone, camphor, methyl ethyl ketone, valencane	Methyl ethyl ketone
Molybdenum	Molybdenum	n/a
Naphthalene group[(a)]	1-Methylnaphthalene, 2-methylnaphthalene, naphthalene, indole	Naphthalene
Nickel	Nickel	n/a
Nitrogen Dioxide	Nitrogen Dioxide	n/a
Selenium	Selenium	n/a
Sulphur Dioxide	Sulphur Dioxide	n/a
Toluene	Toluene	n/a
Trimethylbenzenes	1,2,3-Trimethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene	1,2,4-Trimethylbenzene
Vanadium	Vanadium	n/a
Xylenes	m-Xylene, o-xylene, p-xylene, xylene	n/a
Zinc	Zinc	n/a

(a) The naphthalene group was assessed individually in addition to its inclusion in the aromatic C_9-C_{16} group and LMW PAH group because a more conservative limit was available for the naphthalene group alone than the limits available for the aromatic C_9-C_{16} group and LMW PAH group.

n/a = Not applicable; a surrogate chemical was not required.

Most of the chemicals listed in the initial inventory were retained as COPCs for the SLWRA. The only chemicals not retained from the initial inventory due to a lack of toxicological information and applicable surrogates were:

- particulate matter, $PM_{2.5}$;
- eight alkylated mercaptans, including amyl mercaptan, butyl mercaptan, ethyl mercaptan, isobutyl mercaptan, isopropyl mercaptan, methyl mercaptan, propyl mercaptan and tert-butyl mercaptan; and
- seven alkylated thiophenes, including 1,3-dimethyl thiophene, 2,3-dimethyl thiophene, 2,5-dimethyl thiophene, 2-ethyl thiophene, 2-methyl thiophene, 3-methyl thiophene and thiophene.

3.4.1.2 Receptor Identification

Wildlife species that frequent the area, including resident and migratory populations, could potentially be exposed to chemicals emitted from the Project. To characterize the wildlife receptors, consideration was given to those species likely to be most exposed and sensitive to potential Project releases.

The SLWRA did not evaluate potential risks to wildlife species individually, but rather, compared the predicted environmental media concentrations to guidelines and toxicity data considered to be protective of all wildlife species, including "At Risk" species. Wildlife receptors were assessed under two main headings: mammalian and avian.

3.4.1.3 Exposure Pathway Identification

Following the release of COPCs into the atmosphere from the Project, these chemicals will disperse and deposit into different environmental media. Wildlife receptors could be exposed to the COPCs through inhalation, ingestion or dermal contact. Although inhalation is generally considered to be a minor wildlife exposure pathway (Environment Canada 1994; Suter II et al. 2000; U.S. EPA 1998), this pathway was included in the SLWRA for the following reasons:

- atmospheric emissions were the Project's only emissions identified to be of relevance; and
- many of the COPCs are highly volatile in nature and thus likely to exist in the vapour phase alone.

The inhalation pathway was assessed by comparing maximum predicted ground-level air concentrations to TRVs that represent levels of exposure that are unlikely to result in adverse effects to the wildlife population.

Ingestion was assumed to be the prominent potential route of exposure for the non-volatile COPCs or chemicals that do not degrade in the environment readily and have the potential to accumulate in the terrestrial environment (e.g., metals). Once chemicals are deposited onto the soils, they become incorporated into the upper profile of the soils and will either be re-volatilized, taken up by vegetation, remain deposited on vegetation, or be sequestered into soils and soil-dwelling organisms. These fate processes are dependent on the environmental fate and physico-chemical properties of the COPC.

For the current screening-level SLWRA, predicted soil concentrations were compared to AENV (2007) Soil Quality Guidelines (SQGs) and to United States Environmental Protection Agency (U.S. EPA) (2007a) Ecological Soil Screening Levels (Eco-SSLs) protective of ecological receptors. It was assumed that if predicted COPC concentrations in soil met the AENV and U.S. EPA SQGs and Eco-SSLs, corresponding wildlife food chain concentrations would not pose a risk to local wildlife populations.

Wildlife receptors could potentially be exposed to COPCs through direct contact with environmental media. However, wildlife exposure through dermal contact is likely insignificant relative to the exposure received though other routes, such as ingestion of soils (Suter II et al. 2000). Thus, dermal contact was not evaluated in the SLWRA.

3.4.2 Exposure Assessment

Distinction is made in the exposure assessment between conditions that provide for short-term (i.e., acute) exposure versus those that allow for long-term (i.e., chronic) exposure.

All of the COPCs emitted to air were incorporated in the inhalation assessment, discussed in detail in the section that follows. Deposition of some COPCs emitted to the atmosphere will occur surrounding the Project and a portion of this deposition will be taken up by the soils. Depending on physical and chemical characteristics of each COPC, chemical deposition could affect the chemical concentrations in local soil. Thus, it was necessary to identify those COPCs that, although only emitted into air, would be likely to persist or accumulate in the terrestrial environment in sufficient quantities for wildlife to be exposed via ingestion (i.e., soil ingestion). For this purpose, the list of COPCs may be divided into two general categories:

- Gaseous COPCs (i.e., carbon monoxide [CO], hydrogen sulphide [H_2S], nitrogen dioxide [NO_2] and sulphur dioxide [SO_2]), which, due to their volatile nature, are not likely to contribute to wildlife exposure via secondary pathways. Thus, it is very unlikely that any of the gaseous COPCs emitted to air would deposit on soils in or near the Project area. In addition, the principle health effects of these gaseous COPCs are strictly related to inhalation.
- Non-gaseous COPCs (i.e., Total Reduced Sulphur (TRS) compounds other than H_2S, Volatile Organic Compounds (VOCs), PAHs and metals), which might be deposited in or near the Project area and persist or accumulate in the environment in sufficient quantities for wildlife to be exposed via ingestion (i.e., soil ingestion).

Based on the typical physical-chemical properties of some of the non-gaseous PAHs and metals, it is likely that these COPCs will likely persist or accumulate in the environment at least to some extent. On this basis, PAHs and metals were included in the oral exposure assessment.

To identify the other non-gaseous COPCs that could persist or accumulate in the terrestrial environment, consideration was given to the inherent physical-chemical properties of the COPCs that influence their fate and persistence in the environment and subsequently their potential occurrence in oral exposure pathways (i.e., soil ingestion).

Given the high degree of variation in the physical-chemical properties of the TRS compounds and VOCs, the fate and persistence of these COPCs could not be determined for the chemical categories as a whole. As such, the physical-chemical properties of each of the TRS compounds (with the exception of H_2S) and VOCs were compared against accepted national and international criteria for the classification of persistent, bio-accumulative substances (Environment Canada 2008; Rodan et al. 1999). The criteria are listed below:

- half-life in soil more than or equal to 6 months or 182 days; and
- octanol-water partition coefficient (Log K_{ow}) more than or equal to 5.

This exercise is based on the premise that if a chemical does not meet any of the criteria, the chemical is unlikely to accumulate to appreciable amounts in food items or to persist in the environment and therefore the assessment of oral exposure pathways is not applicable. However, if a chemical meets any of the criteria, sufficient opportunity could be presented for exposure to occur via oral exposure pathways (i.e., soil ingestion).

The non-gaseous substances (other than metals and PAHs) that could persist or accumulate in the terrestrial environment are identified in Table 3.

The findings of the exercise indicate that the following COPCs, in addition to the PAHs and metals, could contribute to wildlife exposure via oral exposure pathways (i.e., soil ingestion):

- aliphatic C_2-C_8 group;
- aliphatic C_9-C_{16} group;
- aliphatic C_{17}-C_{34} group; and
- aromatic C_9-C_{16} group.

These specific COPCs were included in the oral exposure assessment.

Table 3 Identification of Persistent Total Reduced Sulphur Compounds and Volatile Organic Compounds for Inclusion in the Assessment of Secondary Pathways of Exposure

Chemical of Potential Concern[(a)(b)]	Criteria[(c)] Soil Half-Life[(d)] [days]	Criteria[(c)] Log K_{ow}[(e)]	Inclusion in Oral Exposure Assessment[(f)]
Aliphatic C_2-C_8 group	712	3.81	✓
Aliphatic C_9-C_{16} group	1,750	6.91	✓
Aliphatic C_{17}-C_{34} group	–	10.3	✓
Aromatic C_9-C_{16} group	1,750	3.91	✓
Benzene	23	2.1	x
Carbon disulphide group	–	0.80	x
Ethylbenzene	10	3.1	x
Ethylene	–	1.13	x
Formaldehyde	7	0.35	x
Hexane group	–	3	x
Methyl ethyl ketone group	7	3.58	x
Toluene	22	2.7	x
Trimethylbenzenes	–	3.42	x
Xylenes	28	3.2	x
Criteria	**182**	**5**	

(a) By their very nature, gaseous COPCs (i.e., CO, H_2S, NO_2 and SO_2) will remain airborne for extended times and over extended distances; thus, the likelihood that any of the gaseous chemicals emitted to air would deposit near the Project and be available for exposure via secondary pathways is low. On this basis, gaseous COPCs were not included in the oral exposure assessment.

(b) By their very nature, PAHs and metals will deposit near the Project and persist or accumulate in the environment, presenting sufficient opportunity for exposure via ingestion. On this basis, PAHs and metals were included in the oral exposure assessment and were not screened in this table.

(c) Criteria for the chemical groups were based on the highest criteria of the group's individual constituents.

(d) Taken from Mackay et al. (1992) and U.S. EPA OSW (2005). Exceptions are benzene which was cited from Wania and Mackay (2000) and the aliphatic and aromatic groups which were cited from CCME (2000b).

(e) Taken from Mackay et al. (1992), U.S. EPA OSW (2005) and HSDB (2008, Website). Exceptions are the aliphatic and aromatic groups which were cited from CCME (2000).

(f) The COPCs that meet any one of the criteria could present sufficient opportunity for exposure via ingestion.

✓ COPC was included in the oral exposure assessment.

x COPC was not included in the oral exposure assessment.

– = Not available.

3.4.2.1 Inhalation Exposure Assessment

Inhalation exposure estimates were based on the results of air dispersion modelling described in the Air Quality Assessment (Section 1). Predicted air concentrations were presented for different averaging periods (i.e., 1-hour and annual) which were used in the acute and chronic assessments. Predicted ground-level concentrations for the chemical groups were based on the addition of the air concentrations predicted for each of the COPCs included in the chemical group. For example, the ground-level air concentrations predicted for all 102 of the chemicals in the aliphatic C_2-C_8 group were summed to derive a total air concentration for the aliphatic C_2-C_8 group.

Predicted ground-level air concentrations incorporated emissions associated with all major regional sources as well as background community concentrations (Section 1). Background community concentrations were accounted for in the Air Quality Assessment using monitoring data from the Cold Lake South continuous monitoring station. Because the Air Quality Assessment was able to adequately characterize existing conditions in the area, further background concentrations were not added to the predicted values in the SLWRA.

Predicted maximum ground-level air concentrations used in the SLWRA are provided in Tables 4 and 5 on an acute and chronic basis, respectively.

Table 4 Maximum Predicted Short-Term Air Concentrations Used in the Screening Level Wildlife Risk Assessment

Chemical of Potential Concern	Averaging Period	Acute Air Concentrations [µg/m^3]		
		Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1-hour	4.0E+01	4.9E+01	5.3E+01
Aliphatic C_9-C_{16} group	1-hour	1.0E+01	1.1E+01	1.3E+01
Aliphatic C_{17}-C_{34} group	1-hour	9.9E-01	1.4E+00	1.4E+00
Aromatic C_9-C_{16} group	1-hour	1.9E+00	1.9E+00	2.4E+00
Arsenic	1-hour	3.9E-04	1.1E-03	1.1E-03
Barium	1-hour	8.5E-03	2.4E-02	2.4E-02
Benzene	1-hour	1.4E+00	1.4E+00	1.4E+00
Beryllium	1-hour	2.3E-05	6.5E-05	6.5E-05
Cadmium	1-hour	2.2E-03	5.9E-03	5.9E-03
Carbon disulphide group	1-hour	4.9E-01	7.0E-01	7.0E-01
Carbon Monoxide (CO)	1-hour	4.0E+02	4.6E+02	4.6E+02
Chromium	1-hour	2.8E-03	7.6E-03	7.6E-03
Cobalt	1-hour	2.2E-04	4.8E-04	4.8E-04
Copper	1-hour	1.7E-03	4.6E-03	4.6E-03
Ethylbenzene	1-hour	1.5E+00	1.5E+00	1.8E+00
Ethylene	1-hour	5.5E+00	5.5E+00	5.5E+00
Formaldehyde	1-hour	1.8E+00	1.8E+00	1.8E+00
Hexane group	1-hour	8.9E+00	8.9E+00	1.1E+01

Table 4 Maximum Predicted Acute Air Concentrations Used in the Screening Level Wildlife Risk Assessment (continued)

Chemical of Potential Concern	Averaging Period	Acute Air Concentrations [μg/m^3]		
		Existing and Approved Case	Project Case	Planned Development Case
HMW PAH group	1-hour	8.3E-03	8.3E-03	8.3E-03
Hydrogen sulphide	1-hour	5.2E+00	7.5E+00	7.5E+00
Lead	1-hour	9.8E-04	2.7E-03	2.7E-03
LMW PAH group	1-hour	1.6E-01	1.6E-01	1.6E-01
Manganese	1-hour	7.7E-04	2.1E-03	2.1E-03
Mercury	1-hour	5.0E-04	1.4E-03	1.4E-03
Methyl ethyl ketone group	1-hour	9.5E-01	9.5E-01	9.5E-01
Molybdenum	1-hour	2.1E-03	5.9E-03	5.9E-03
Naphthalene group	1-hour	1.5E-01	1.5E-01	1.5E-01
Nickel	1-hour	4.3E-03	1.2E-02	1.2E-02
Nitrogen dioxide	1-hour	8.5E+01	1.6E+02	1.6E+02
Selenium	1-hour	6.5E-04	6.5E-04	6.5E-04
Sulphur dioxide	1-hour	2.8E+02	4.2E+02	4.2E+02
Toluene	1-hour	2.6E+00	2.6E+00	3.5E+00
Trimethylbenzenes	1-hour	3.6E-01	3.6E-01	4.8E-01
Vanadium	1-hour	6.1E-03	1.3E-02	1.3E-02
Xylenes	1-hour	3.2E+00	3.2E+00	4.0E+00
Zinc	1-hour	5.7E-02	1.6E-01	1.6E-01

Table 5 Maximum Predicted Long-Term Air Concentrations Used in the Screening Level Wildlife Risk Assessment

Chemical of Potential Concern[(a)]	Chronic Air Concentrations [μg/m^3]		
	Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	3.9E+00	3.9E+00	4.4E+00
Aliphatic C_9-C_{16} group	1.3E+00	1.3E+00	1.4E+00
Aliphatic C_{17}-C_{34} group	1.8E-01	1.8E-01	1.8E-01
Aromatic C_9-C_{16} group	1.1E-01	1.1E-01	1.3E-01
Arsenic	2.1E-05	3.5E-05	3.7E-05
Barium	4.5E-04	7.5E-04	8.0E-04
Benzene	2.7E-01	2.7E-01	2.7E-01
Beryllium	1.3E-06	2.1E-06	2.2E-06
Cadmium	1.2E-04	2.0E-04	2.1E-04
Carbon disulphide group	2.5E-02	4.6E-02	4.6E-02
Chromium	1.7E-04	2.7E-04	2.8E-04
Cobalt	1.4E-05	2.0E-05	2.2E-05
Copper	9.1E-05	1.5E-04	1.6E-04
Ethylbenzene	4.5E-02	4.5E-02	5.5E-02
Ethylene	1.0E+00	1.0E+00	1.0E+00
Formaldehyde	2.2E-01	2.2E-01	2.2E-01
Hexane group	2.7E-01	3.6E-01	4.3E-01
HMW PAH group	5.5E-04	5.5E-04	5.6E-04
Hydrogen sulphide	2.6E-01	4.8E-01	4.8E-01
Lead	5.6E-05	9.0E-05	9.7E-05

Table 5 Maximum Predicted Chronic Air Concentrations Used in the Screening Level Wildlife Risk Assessment (continued)

Chemical of Potential Concern[(a)]	Chronic Air Concentrations [μg/m^3]		
	Existing and Approved Case	Project Case	Planned Development Case
LMW PAH group	1.0E-02	1.0E-02	1.1E-02
Manganese	5.2E-05	7.8E-05	8.3E-05
Mercury	2.7E-05	4.4E-05	4.7E-05
Methyl ethyl ketone group	1.9E-01	1.9E-01	1.9E-01
Molybdenum	1.2E-04	1.9E-04	2.0E-04
Naphthalene group	9.8E-03	9.9E-03	1.0E-02
Nickel	3.2E-04	4.6E-04	5.0E-04
Nitrogen dioxide	3.8E+00	5.1E+00	6.1E+00
Selenium	1.6E-05	1.7E-05	1.7E-05
Sulphur dioxide	6.5E+00	1.6E+01	1.6E+01
Toluene	2.8E-01	2.8E-01	3.3E-01
Trimethylbenzenes	1.8E-02	1.8E-02	2.4E-02
Vanadium	3.5E-04	5.0E-04	5.6E-04
Xylenes	1.6E-01	1.6E-01	1.9E-01
Zinc	3.1E-03	5.1E-03	5.4E-03

(a) Carbon monoxide was not included in the chronic inhalation assessment due to the lack of an adequate chronic inhalation TRV.

3.4.2.2 Oral Exposure Assessment

Chemicals of Potential Concern determined to have the potential to persist or accumulate in the environment were evaluated using both ambient measurements and predicted soil concentrations.

Ambient Measurements

Measured data were used whenever possible to characterize the background concentrations of the COPCs in soil. Soil concentrations were measured within the Project area as well as the surrounding landscape. Soil samples were collected from eleven sampling locations identified within the Christina Lake area and were analyzed for a suite of PAHs and metals. The 95 percent upper confidence interval on the mean (95 UCLM) was used to characterize background soil concentrations of the COPCs in the region. For some metals, soil samples were all below the Method Detection Level (MDL) or were not consistent with regional measured data. Under these circumstances, measured concentrations collected in support of other, nearby applications were used to characterize background or ambient concentrations (e.g., EnCana FCCL Oil Sands Ltd.'s (EnCana's) Christina Lake Thermal Project).

Predictive Exposure Modelling

Predictive modelling was used to estimate the concentrations of the COPCs in soil that lack measured concentrations (i.e., data gaps) or to predict future concentrations (i.e., incremental changes). The soil concentrations were predicted using mathematical equations (algorithms) that define the movement of the COPCs from the Project onto the soil.

The COPC concentrations in soil were predicted for the EAC (in addition to measured concentrations), Project Case and PDC. Soil concentrations were predicted using the maximum annual average air concentrations of the locations identified in the HHRA (Volume 3, Section 3.4.4.1). Use of the maximum predicted air concentration is likely conservative as wildlife typically forage throughout the area, and thus would not be continuously exposed to the highest annual air concentration over their lifetime.

Conservative assumptions were included in the prediction of potential soil concentrations as the calculation did not incorporate estimates of chemical losses over time from runoff, leaching, or wind erosion. Potential soil losses from abiotic and biotic degradation and volatilization were estimated.

Predicted and measured soil concentrations assumed in the SLWRA are provided in Table 6.

Table 6 Predicted Soil Concentrations in the Study Area

Chemical of Potential Concern[(a)]	Soil Concentrations [mg/kg]		
	Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1.6E-06	1.6E-06	1.8E-06
Aliphatic C_9-C_{16} group	1.2E-04	1.2E-04	1.4E-04
Aliphatic C_{17}-C_{34} group	4.9E-04	4.9E-04	5.0E-04
Aromatic C_9-C_{16} group	2.5E-04	2.5E-04	2.9E-04
Arsenic	6.4E-01	6.4E-01	6.5E-01
Barium	1.9E+01	1.9E+01	1.9E+01
Beryllium	1.4E-01	1.4E-01	1.4E-01
Cadmium	1.8E-01	2.0E-01	2.0E-01
Chromium	2.9E+00	2.9E+00	2.9E+00
Cobalt	1.3E+00	1.3E+00	1.3E+00
Copper	3.2E+00	3.2E+00	3.2E+00
HMW PAH group	5.4E-03	5.4E-03	5.5E-03
Lead	2.3E+00	2.3E+00	2.3E+00
LMW PAH group	4.4E-05	4.4E-05	4.5E-05
Manganese	6.3E+01	6.3E+01	6.3E+01
Mercury	3.3E-02	3.7E-02	3.8E-02
Molybdenum	1.9E-01	2.0E-01	2.1E-01

Table 6 Predicted Soil Concentrations in the Study Area (continued)

Chemical of Potential Concern[(a)]	Soil Concentrations [mg/kg]		
	Existing and Approved Case	Project Case	Planned Development Case
Naphthalene group	5.8E-06	5.9E-06	6.0E-06
Nickel	3.1E+00	3.1E+00	3.1E+00
Selenium	4.7E-01	4.7E-01	4.7E-01
Vanadium	6.2E+00	6.3E+00	6.3E+00
Zinc	1.3E+01	1.3E+01	1.3E+01

(a) Soil concentrations were predicted only for those COPCs that could persist or accumulate in the environment (see Exposure Assessment, Section 3.6.2).

3.4.3 Toxicity Assessment

The toxicity assessment of the SLWRA is concerned with identifying and understanding the potential population health effects that could be caused by the COPCs under different conditions of exposure and using this health effects information to define safe levels of exposure. A distinction was made between the health effects caused by acute and chronic exposures in recognition of the variability in response that may be seen by the same COPC following different exposure durations. The safe level of exposure or TRV refers to the amount or dose of the COPC that is unlikely to produce adverse health effects at a population level.

3.4.3.1 Inhalation Exposure

Much of the information respecting the health effects of the COPCs was obtained from the medical and scientific literature, and referred to the findings from biomedical research involving the exposure of laboratory test animals such as mice, rats and rabbits. Virtually no studies have been identified in which wildlife species are exposed to the COPCs under controlled conditions. The lack of studies presents three challenges:

- Health effects data gathered from the laboratory animals must be extrapolated or “translated” to the wildlife species. This extrapolation of the data requires the use of “uncertainty” factors to account for possible differences in physiology and sensitivity to the chemicals that might exist between the species. Use of such uncertainty factors in extrapolating the responses witnessed in one species to another is a common practice in risk assessment.
- The study designs used in toxicity studies (i.e., exposure of the laboratory test animal to near maximum tolerated concentrations of the chemicals) lead to research findings often showing adverse health

effects. The differences between the concentrations tested in the laboratory and those to which wildlife might be exposed must be considered to fully assess the significance of the information. In many cases, the concentrations tested in the laboratory animals are considerably higher than those that might be encountered by wildlife in the field.

- The bioaccessibility or bioavailability (i.e., chemical form) in which the compound is introduced to the test organism is designed to maximize uptake into the blood stream (i.e., use of dissolved metals in water or administered as salt solutions). Bioaccessibility is maximized in the lab to maximize toxic effects. The uptake of the highly bioaccessible form often results in strikingly different exposures in the environment where chemicals are often bound to compounds that dramatically reduce uptake (e.g., sulphide and phosphate form of metals).

Acute and chronic inhalation TRVs were developed for all COPCs, when possible.

Acute Toxicity Reference Values

Information regarding the acute toxicity of pollutants in wildlife species and “regulatory limits” developed for wildlife species were not available. For most of the COPCs, a number of LC_{50} values have been reported for laboratory animal species. The LC_{50} is the air concentration that is associated with lethality in 50% of the test animals. The acute inhalation TRVs were derived based on the lowest LC_{50} value reported in the literature. If an LC_{50} value was not available, then an LC_{Lo}, No Observable Adverse Effects Level (NOAEL) or Lowest Observable Adverse Effects Level (LOAEL) value was used. The LC_{Lo} refers to the “lowest published lethal concentration” (NTP 2008, Website). Use of the lowest values reduces the likelihood that potential risks are underestimated.

Since the lowest value reported for all species was used to derive the acute TRV, no uncertainty factors were applied to account for possible differences in sensitivity between species. All mammalian wildlife receptors were evaluated under one acute TRV identified based on the lowest LC_{50} value for all mammalian laboratory animals. Similarly, all avian wildlife receptors were evaluated under one acute TRV identified based on the lowest LC_{50} value reported for all bird species.

The literature review for LC_{50} values consisted of an online search of the following:

- International Programme on Chemical Safety (IPCS);
- National Toxicity Program Chemical Repository (NTP);
- National Library of Medicine’s Hazardous Substances Data Bank (HSDB);
- National Library of Medicine’s ChemIDPlus; and
- Agency for Toxic Substances and Disease Registry (ATSDR).

The TRVs used to evaluate potential health risks associated with acute inhalation exposure are provided in Table 7.

Table 7 Acute Inhalation Wildlife Toxicity Reference Values

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Aliphatic C_2-C_8 group	Avian	3,500	Growth	LOAEL of 3,500 mg/m^3 in Leghorn hens exposed for 30 days continuously to n-hexane vapours.	Abou-Donia et al. 1991
	Mammal	10,000	Maternal toxicity	A NOAEL of 10,000 mg/m^3 was identified in rats and mice exposed via inhalation to commercial hexane for 6 hours per day, on days 6-15 of gestation.	TPHCWG 1997
Aliphatic C_9-C_{16} group	Avian	–	–	–	–
	Mammal	1,910	Growth	A NOAEL of 1,910 mg/m^3 was identified in rats exposed via inhalation to dearomatized white spirit vapours for 6 hours per day, 5 days per week, for 12 weeks.	MA DEP 2003
Aromatic C_9-C_{16} group	Avian	–	–	–	–
	Mammal	500	Growth	A NOAEL of 500 mg/m^3 was identified in mice exposed via inhalation to high flash aromatic naphtha for 6 hours per day on gestational days 6-15.	TPHCWG 1997; MA DEP 2003
Arsenic	Avian	–	–	–	–
	Mammal	100	Lethality	An LC_{Lo} of 100 mg/m^3 was identified in cats exposed via inhalation to arsenic trichloride for 1 hour.	NIOSH 1995. Website
Benzene	Avian	–	–	–	–
	Mammal	15,000	Lethality	An LC_{50} of 15,000 mg/m^3 was identified in mice exposed via inhalation to benzene for 8 hours.	IPCS 1993, Website
Beryllium	Avian	–	–	–	–
	Mammal	0.15	Lethality	An LC_{50} of 0.15 mg/m^3 was identified in rats exposed via inhalation to beryllium for 4 hours.	IPCS 2001°, Website
Cadmium	Avian	–	–	–	–
	Mammal	28.4	Lethality	An LC_{50} of 28.4 mg/m^3 was identified in rabbits exposed via inhalation to cadmium metal dust for 4 hours.	ATSDR 1999a
Carbon disulphide group	Avian	–	–	–	–
	Mammal	690	Lethality	An LC_{50} of 690 mg/m^3 was identified in mice exposed via inhalation to carbon disulphide for 1 hour.	IPCS 2002, Website
Carbon monoxide	Avian	1,500	Lethality	An LC_{50} of 1,334 ppm (1,500 mg/m^3) was identified in wild birds.	NTP 2008, Website
	Mammal	2,078	Lethality	An LC_{50} of 2,078 mg/m^3 was identified in rats exposed via inhalation to carbon monoxide for 4 hours.	Ramamoorthy et al. 1995

Table 7 Acute Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Chromium	Avian	–	–	–	–
	Mammal	31.5	Lethality	An LC_{50} of 31.5 mg/m^3 was identified in mice exposed via inhalation to chromium (III) chloride for 2 hours.	ChemIDplus 2008, Website
Cobalt	Avian	–	–	–	–
	Mammal	165	Lethality	An LC_{50} of 165 mg/m^3 was identified in rats exposed via inhalation to cobalt hydrocarbonyl for 30 minutes.	IPCS 2006, Website
Copper	Avian	–	–	–	–
	Mammal	1,303	Lethality	An LC_{50} greater than 1,303 mg/m^3 was identified in rabbits exposed via inhalation to copper (II) hydroxide (duration unknown).	IPCS 1998, Website
Ethylbenzene	Avian	–	–	–	–
	Mammal	17,200	Lethality	An LC_{50} of 17,200 mg/m^3 was identified in rats exposed via inhalation to ethylbenzene for 4 hours.	IPCS 1996, Website
Ethylene	Avian	–	–	–	–
	Mammal	–	–	–	–
Formaldehyde	Avian	–	–	–	–
	Mammal	414	Lethality	An LC_{50} of 414 mg/m^3 was identified in mice exposed via inhalation to formaldehyde for 4 hours.	HSDB 2008, Website
Hexane group	Avian	3,500	Growth	A LOAEL of 3,500 mg/m^3 was identified in Leghorn hens exposed continuously to n-hexane vapours for 30 days.	Abou-Donia et al. 1991
	Mammal	169,000	Lethality	An LC_{50} of 48,000 ppm (169,000 mg/m^3) was identified in mice and rats exposed via inhalation to hexane for 4 hours.	HSDB 2008, Website
HMW PAH group	Avian	–	–	–	–
	Mammal	–	–	–	–
Hydrogen sulphide	Avian	–	–	–	–
	Mammal	820	Lethality	An LC_{50} of 820 mg/m^3 was identified in mice exposed via inhalation to hydrogen sulphide for 2 hours.	Prior et al. 1988, Website
Lead	Avian	–	–	–	–
	Mammal	–	–	–	–
LMW PAH group	Avian	–	–	–	–
	Mammal	–	–	–	–

Table 7 Acute Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Manganese	Avian	–	–	–	–
	Mammal	61	Reproductive	A NOAEL of 61 mg/m^3 was identified in mice exposed via inhalation to manganese dioxide for 7 hours per day, 5 days per week for 18 weeks.	ATSDR 2000a
Mercury	Avian	–	–	–	–
	Mammal	29	Lethality	An LC_{Lo} of 29 mg/m^3 was identified in rabbits exposed via inhalation to mercury for 30 hours.	ChemIDplus 2008, Website
Methyl ethyl ketone group	Avian	–	–	–	–
	Mammal	32,000	Lethality	An LC_{50} of 32,000 mg/m^3 was identified in mice exposed via inhalation to 2-butanone for 4 hours.	NTP 2008, Website
Molybdenum	Avian	–	–	–	–
	Mammal	5,840	Lethality	An LC_{50} of 5,840 mg/m^3 was identified in rats exposed via inhalation to molybdenum trioxide for 4 hours.	ChemIDplus 2008, Website
Naphthalene group	Avian	–	–	–	–
	Mammal	340	Lethality	An LC_{50} of 340 mg/m^3 was identified in rats exposed via inhalation to naphthalene for 1 hour. The LC_{50} for naphthalene is more conservative than the TRV used for the aromatic C_9-C_{16} group, thus the naphthalene group was assessed both individually and as part of the aromatic C_9-C_{16} group.	NTP 2008, Website
Nickel	Avian	–	–	–	–
	Mammal	67	Lethality	An LC_{50} of 67 mg/m^3 was identified in mice exposed via inhalation to nickel carbonyl for 30 minutes.	HSDB 2008, Website
Nitrogen dioxide	Avian	–	–	–	–
	Mammal	56	Lethality	An LC_{50} of 56 mg/m^3 was identified in guinea pigs exposed via inhalation to nitrogen dioxide for 1 hour.	HSDB 2008, Website
Selenium	Avian	–	–	–	–
	Mammal	33	Lethality	An LC_{Lo} of 33 mg/m^3 was identified in rats exposed via inhalation to selenium for 8 hours.	ChemIDplus 2008, Website
Sulphur dioxide	Avian	2,600	Lethality	An LC_{20} of 1,000 ppm (2,600 mg/m^3) was identified in White Leghorn poultry continuously exposed to sulphur dioxide vapours of 0 to 5,000 ppm for 1 hour.	Fedde and Kuhlmann 1979
	Mammal	2,600	Lethality	An LC_{50} of 2,600 mg/m^3 was identified in mice exposed via inhalation to sulphur dioxide for 4 hours.	HSDB 2008, Website

Table 7 Acute Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Toluene	Avian	–	–	–	–
	Mammal	100,000	Lethality	An LC_{50} of 100,000 mg/m^3 was identified in rats exposed via inhalation to toluene for 1 hour.	HSDB 2008, Website
Trimethylbenzenes	Avian	–	–	–	–
	Mammal	24,000	Lethality	An LC_{50} of 24,000 mg/m^3 was identified in rats exposed via inhalation to 1,3,5-trimethylbenzene for 4 hours.	ChemIDplus 2008, Website
Vanadium	Avian	–	–	–	–
	Mammal	70	Lethality	An LC_{50} of 70 mg/m^3 was identified in rats exposed via inhalation to vanadium pentoxide fume for 1 hour.	HSDB 2008, Website
Xylenes	Avian	–	–	–	–
	Mammal	17,000	Lethality	An LC_{50} of 17,000 mg/m^3 was identified in mice exposed via inhalation to xylene for 6 hours.	HSDB 2008, Website
Zinc	Avian	–	–	–	–
	Mammal	1,975	Lethality	An LC_{50} of 1,975 mg/m^3 was identified in rats exposed via inhalation to zinc chloride for 10 minutes.	HSDB 2008, Website

– = No data available.

Chronic Toxicity Reference Values

Very little standardized guidance on the derivation of chronic wildlife TRVs is provided in the form of regulatory guidelines, directives or protocols. In 1998, the British Columbia Ministry of Water, Land and Air Protection (BC MWLAP 1998) recommended an approach for the extrapolation of toxicity data between mammalian species based on an EC_{20} or concentration that affects 20% of the exposed (i.e., test) organisms. The BC MWLAP (1998) gave preference to reproductive endpoints, but lethality, growth and developmental effects were considered to be acceptable if these are the only endpoints available. According to the BC MWLAP (1998), an uncertainty factor of 10 should be applied to the EC_{20} to account for interspecies differences. If an EC_{20} is not available, then the BC MWLAP (1998) recommends that a concentration curve be generated from the available toxicity data. Otherwise, the use of a LOAEL is recommended without any application of uncertainty factors.

A summary of the BC MWLAP (1998) recommendations for ecological risk assessments follows:

- use an EC_{20} as a TRV;
- if an EC_{20} is not available or cannot be calculated, use the LOAEL from the most applicable study;
- if the data are from similar species do not use uncertainty factors; and
- if the animals are not so closely related or if it is unknown whether or not they are likely to have similar physiological responses, apply an uncertainty factor of 10.

The U.S. EPA (1998a) provides guidance for deriving chronic TRVs using NOAELs based on population-level effects for chronic exposure, such as development, reproduction and survivorship, whereas the CCME (1996) recommends using a LOAEL and applying an uncertainty factor of 1 to 5, based on expert judgment, for extrapolation between wildlife species.

For most of the COPCs, EC_{20} values were not identified. For the chronic inhalation TRVs, reliance was placed on NOAELs as opposed to LOAELs to reduce the likelihood of the underestimation of potential risks to sensitive wildlife species. The lowest reported NOAEL value for all species associated with population-level effects was selected. Due to the similarity in respiratory physiology between different species, no adjustments were made to the NOAEL for the individual wildlife receptors. The lowest NOAEL identified for mammalian laboratory animals was used to evaluate potential risks to all the mammalian wildlife receptors and the lowest NOAEL for birds was used to evaluate potential risks to all the avian wildlife receptors.

The literature review for NOAEL values consisted of an online search of the following:

- Health Canada and Environment Canada;
- U.S. EPA;
- World Health Organization (WHO);
- ATSDR;
- American Conference of Governmental Industrial Hygienists (ACGIH);
- California's Office of Environmental Health Hazard Assessment (OEHHA);
- Netherlands' National Institute of Public Health and the Environment (RIVM);
- Ontario Ministry of the Environment (OMOE);
- International Programme on Chemical Safety (IPCS);
- National Toxicology Program Chemical Repository (NTP);
- National Library of Medicine's Hazardous Substances Data Bank (HSDB); and
- National Library of Medicine's Toxicology Literature Online (TOXLINE).

For many of the COPCs, a TRV was derived from the available toxicological data. A review of toxicological data specific to each species was evaluated and an EC_{20} or a geometric mean of the growth and reproduction effect data was calculated when sufficient data was available. If sufficient data was not available, a LOAEL was recommended as the TRV or a NOAEL for sensitive species. The TRVs were based on ecologically relevant endpoints (i.e., growth, reproduction and survivorship).

If sufficient toxicity information was not available for a given receptor and chemical combination then risks were not evaluated in the SLWRA.

A summary of the TRVs used to evaluate potential wildlife health risks associated with chronic inhalation exposure are provided in Table 8.

Table 8 Chronic Inhalation Wildlife Toxicity Reference Values

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Aliphatic C_2-C_8 group	Avian	35	Growth effects	A LOAEL of 3,500 mg/m^3 was identified in Leghorn hens exposed continuously to n-hexane vapours for 30 days. An uncertainty factor of 100 was applied to account for use of a subchronic study and a LOAEL.	Abou-Donia et al. 1991
	Mammal	1,840	Reproductive effects	A NOAEL of 3000 ppm (10,307 mg/m^3) was identified in rats exposed to 0, 900, 3000, or 9000 ppm commercial hexane for 6 hours per day, 5 days per week for 2 generations. The NOAEL was adjusted to continuous exposure.	TPHCWG 1997
Aliphatic C_9-C_{16} group	Avian	–	–	–	–
	Mammal	35	Growth effects	A NOAEL of 300 ppm (1,970 mg/m^3) was identified in rats exposed via inhalation to dearomatized white spirit vapours for 6 hours per day, 5 days per week for 12 weeks. The NOAEL was adjusted to continuous exposure. An uncertainty factor of 10 was applied to account for use of a subchronic study.	MA DEP 2003
Aromatic C_9-C_{16} group	Avian	–	–	–	–
	Mammal	123	Developmental/ reproductive effects	A NOAEL of 100 ppm (491 mg/m^3) was identified in mice exposed to 0, 100, 500 or 1,500 ppm high flash aromatic naphtha (HFAN) for 6 hours per day on gestation days 6-15. A three-generation reproductive study using the same exposure concentrations also identified a NOAEL of 100 ppm. The NOAEL was adjusted to continuous exposure.	MA DEP 2003
Arsenic	Avian	–	–	–	–
	Mammal	2	Developmental/ reproductive effects	A NOAEL of 8 mg/m^3 was identified in rats exposed to 0.2 to 8 mg/m^3 arsenic (as arsenic trioxide) for 6 hours per day from 14 days prior to mating through gestation day 19. The NOAEL was adjusted to continuous exposure.	ATSDR 2007
Barium	Avian	–	–	–	–
	Mammal	0.11	Growth effects	A NOAEL of 0.8 mg/m^3 was identified in rats exposed to 0.8 or 3.6 mg/m^3 barium (as barium carbonate dust) for 4 hours per day, 6 days per week for 4 months. The NOAEL was adjusted to continuous exposure.	IPCS 2001b, Website; RIVM 2001; U.S. EPA 1998a, Website
Benzene	Avian	–	–	–	–
	Mammal	15	Developmental effects	A LOAEL of 47 ppm (150 mg/m^3) was identified in rats exposed to 0, 47, 141, 470, or 939 ppm benzene for 24 hours per day on gestation days 7-14. An uncertainty factor of 10 was applied for use of a LOAEL.	CEPA 1993

Table 8 Chronic Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Beryllium	Avian	–	–	–	–
	Mammal	0.038	Growth effects	A NOAEL of 0.21 mg/m^3 was identified in rats exposed to bertrandite ore for 6 hours per day, 5 days per week for up to 17 months. The NOAEL was adjusted to continuous exposure.	U.S. EPA 1998b, Website; ATSDR 2002
Cadmium	Avian	–	–	–	–
	Mammal	0.00030	Developmental effects	A LOAEL of 0.02 mg/m^3 was identified in rats exposed to cadmium (as cadmium oxide) for 5 hours per day, 5 days per week for 5 months prior to mating, during mating and the first 20 days of gestation. The LOAEL was adjusted to continuous exposure. An uncertainty factor of 10 was applied for use of a LOAEL.	ATSDR 1999a; CEPA 1994
Carbon disulphide group	Avian	–	–	–	–
	Mammal	26	Developmental effects	A NOAEL of 40 ppm (125 mg/m^3) was identified in rats and rabbits exposed to 0, 20, or 40 ppm carbon disulphide for 7 hours per day, 5 days per week during pregestational and/or gestational periods. The NOAEL was adjusted to continuous exposure.	ATSDR 1996; CEPA 2000; U.S. EPA 1995°, Website
Chromium	Avian	–	–	–	–
	Mammal	0.092	Reproductive and growth effects	A NOAEL of 0.1 mg/m^3 was identified in rats exposed to a 3:2 mixture of chromium(VI) trioxide and chromium(III) oxide for 22 hours per day, 7 days per week for 18 months. The NOAEL was adjusted to continuous exposure.	ATSDR 2000b
Cobalt	Avian	–	–	–	–
	Mammal	0.0020	Reproductive effects	A LOAEL of 1.14 mg/m^3 was identified in mice exposed to 0, 1.14, 3.80 or 11.38 mg/m^3 cobalt (as cobalt sulphate heptahydrate) for 6 hours per day, 5 days per week for 13 weeks. The LOAEL was adjusted to account to continuous exposure. An uncertainty factor of 10 was applied for use of a LOAEL and an uncertainty factor of 10 was applied for use of a subchronic study. A similar study exposed mice to 0, 0.11, 0.38, 1.14 or 3.8 mg/m^3 for 6 hours per day, 5 days per week for 105 weeks. Growth effects were observed at all exposures. Adjustment of the lowest exposure (i.e., 0.11 mg/m^3) to continuous exposure and application of an uncertainty factor of 10 for lack of a NOAEL also results in a TRV of 0.0020 mg/m^3.	ATSDR 2004; IPCS 2006, Website
Copper	Avian	–	–	–	–
	Mammal	0.25	Respiratory effects	A LOAEL of 2.5 mg/m^3 was identified in rats exposed to 2.5 or 19.6 mg/m^3 copper (as copper chloride) for 4 months. An uncertainty factor of 10 was applied to account for use of a LOAEL.	IPCS 1998, Website

Table 8 Chronic Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Ethylbenzene	Avian	–	–	–	–
	Mammal	110	Developmental effects	A NOAEL of 100 ppm (434 mg/m^3) was identified in New Zealand white rabbits exposed to 0, 100, or 1000 ppm ethylbenzene for 6-7 hours per day, 7 days per week on gestation days 1-24. The NOAEL was adjusted to continuous exposure.	U.S. EPA 1991a, Website
Ethylene	Avian	–	–	–	–
	Mammal	615	Kidney and nasal effects	A NOAEL of 3,000 ppm (3,440 mg/m^3) was identified in Fischer 344 rats exposed to 0, 300, 1000 or 3000 ppm ethylene for 6 hours per day, 5 days per week for 106 weeks. The NOAEL was adjusted to continuous exposure.	ACGIH 2005
Formaldehyde	Avian	–	–	–	–
	Mammal	0.45	Survivorship and growth effects	A NOAEL of 2 ppm (2.5 mg/m^3) was identified in rats exposed to 0, 2, 5.6, or 14.3 ppm formaldehyde for 6 hours per day, 5 days per week, for 24 months. The NOAEL was adjusted to continuous exposure.	U.S. EPA 1991b, Website
Hexane group	Avian	35	Growth effects	A LOAEL of 3,500 mg/m^3 was identified in Leghorn hens exposed continuously to n-hexane vapours for 30 days. An uncertainty factor of 100 was applied to account for use of a subchronic study and a LOAEL.	Abou-Donia et al. 1991
	Mammal	580	Developmental effects	A NOAEL of 200 ppm (700 mg/m^3) was identified in rats exposed to 0, 200, 1000 or 5000 ppm hexane vapours for 20 hours per day on days 6-19 of gestation. The NOAEL was adjusted to continuous exposure.	ATSDR 1999b; U.S. EPA 2005, Website
HMW PAH group	Avian	–	–	–	–
	Mammal	–	–	–	–
Hydrogen sulphide	Avian	–	–	–	–
	Mammal	7.6	Growth effects	A NOAEL of 30.5 ppm (42.5 mg/m^3) was identified in rats and mice exposed to 0, 10.1, 30.5, or 80 ppm hydrogen sulphide for 6 hours per day, 5 days per week for 90 days. The NOAEL was adjusted to continuous exposure.	U.S. EPA 2003a, Website; ATSDR 2006
LMW PAH group	Avian	–	–	–	–
	Mammal	–	–	–	–
Lead	Avian	–	–	–	–
	Mammal	–	–	–	–
Manganese	Avian	–	–	–	–
	Mammal	0.11	Growth effects	A NOAEL of 0.11 mg/m^3 was identified in rats exposed to 11.6, 112.5 or 1,152 µg/m^3 manganese (as Mn_3O_4) continuously for 9 months.	OEHHA 2007, Website

Table 8 Chronic Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Mercury	Avian	–	–	–	–
	Mammal	0.1	Developmental effects	A NOAEL of 0.1 mg/m^3 was identified in rats exposed to 0.1, 0.5 or 1.0 mg/m^3 mercury vapour throughout the gestational period (days 1 to 20).	U.S. EPA 1995b, Website
Methyl ethyl ketone group	Avian	–	–	–	–
	Mammal	870	Developmental effects	A NOAEL of 1,010 ppm (2,980 mg/m^3) was identified in mice exposed to 0, 398, 1,010, or 3,020 ppm 2-butanone for 7 hours per day on gestation days 6-15. The NOAEL was adjusted to continuous exposure.	U.S. EPA 2003b, Website
Molybdenum	Avian	–	–	–	–
	Mammal	10	Growth effects	A NOAEL of 100 mg/m^3 was identified in rats and mice exposed to molybdenum trioxide in a semichronic study. An uncertainty factor of 10 was applied to account for use of a semichronic study.	RIVM 2001
Naphthalene group	Avian	–	–	–	–
	Mammal	9.4	Growth effects	A NOAEL of 10 ppm (52.4 mg/m^3) was identified in rats exposed to 0, 10, 30, or 60 ppm naphthalene vapours for 6 hours per day, 5 days per week for 2 years. The NOAEL was adjusted to continuous exposure.	ATSDR 2005a
Nickel	Avian	–	–	–	–
	Mammal	0.020	Growth effects	A NOAEL of 0.11 mg/m^3 was identified in rats exposed to 0, 0.11 or 0.73 mg/m^3 nickel (as nickel subsulphide) for 6 hours per day, 5 days per week for 104 weeks. The NOAEL was adjusted to continuous exposure.	ATSDR 2005b; OEHHA 2007, Website
Nitrogen dioxide	Avian	–	–	–	–
	Mammal	0.025	Developmental effects	A NOAEL of 0.10 mg/m^3 was identified in rats exposed to 0, 0.05, 0.10, 1.0 or 10 mg/m^3 nitrogen dioxide for 6 hours per day, 7 days per week, through gestation until the offspring were 2 months old. The NOAEL was adjusted to continuous exposure.	Tabacova et al. 1985
Selenium	Avian	–	–	–	–
	Mammal	–	–	–	–
Sulphur dioxide	Avian	–	–	–	–
	Mammal	2.6	Respiratory effects	A NOAEL of 2.6 mg/m^3 was identified in guinea pigs exposed continuously to an average sulphur dioxide concentration of 0.34, 2.6, or 15 mg/m^3 for 52 weeks.	HSDB 2008, Website
Toluene	Avian	–	–	–	–
	Mammal	7.3	Reproductive effects	A LOAEL of 100 ppm (375 mg/m^3) was identified in mice exposed to toluene vapours for 6.5 hours per day, 5 days per week for 14 weeks. The LOAEL was adjusted to continuous exposure. An uncertainty factor of 10 was applied for use of a LOAEL.	CEPA 1992; ATSDR 2000c

Table 8 Chronic Inhalation Wildlife Toxicity Reference Values (continued)

Chemical of Potential Concern	Receptor	Toxicity Reference Value [mg/m^3]	Endpoint	Rationale	Reference
Trimethylbenzenes	Avian	–	–	–	–
	Mammal	370	Developmental effects	A NOAEL of 300 ppm (1,476 mg/m^3) was identified in rats exposed to 0, 100, 300, 600 or 900 ppm 1,2,4-trimethylbenzene vapour and 0, 100, 300, 600 or 1,200 ppm 1,3,5-trimethylbenzene vapour for 6 hours per day on gestation days 6-20. The NOAEL was adjusted to continuous exposure.	OMOE 2006
Vanadium	Avian	–	–	–	–
	Mammal	0.0089	Respiratory effects	A NOAEL of 0.5 mg/m^3 was identified in rats and mice exposed to vanadium pentoxide for 6 hours per day, 5 days per week for 13 weeks. The NOAEL was adjusted to continuous exposure. An uncertainty factor of 10 was applied to account for subchronic exposure.	IPCS 2001c, Website
Xylenes	Avian	–	–	–	–
	Mammal	15	Developmental effects	A LOAEL of 150 mg/m^3 was identified in rats exposed continuously to xylenes on gestation days 7-14. An uncertainty factor of 10 was applied for use of a LOAEL.	ATSDR 2005c
Zinc	Avian	–	–	–	–
	Mammal	–	–	–	–

(a) A chronic inhalation TRV was not developed for carbon monoxide because the critical effect of CO exposure is the formation of carboxyhemoglobin (COHb) in blood. Because COHb concentrations reach a steady-state after six to eight hours of exposure, CO exposure for longer periods (i.e., chronic exposure) is not expected to cause accumulation of COHb in the blood (WHO 2000, Website).

– = No data available.

3.4.3.2 Oral Exposures

Potential risks associated with oral exposures were evaluated using SQGs developed by AENV and the CCME or Eco-SSLs developed by the U.S. EPA.

The SQGs selected for the SLWRA were developed to be protective of wildlife soil and food ingestion for the most stringent land use (i.e., agricultural or natural land use) (AENV 2007; CCME 2006). The soil guidelines developed by AENV (2007) were calculated using models consistent with those employed in CCME (2006) protocols.

The Eco-SSL refers to the concentration of a contaminant in soil that is considered protective of ecological receptors that come in contact with and/or consume biota that live in or on the soil (U.S. EPA 2007a). The U.S. EPA uses a two-step approach to derive the Eco-SSLs. In the first step, TRVs were developed for a mammalian and avian receptor. In deriving the TRVs for the Eco-SSLs, the U.S. EPA used a “weight-of-evidence” approach and conducted comprehensive literature reviews of available toxicity data for avian or mammalian species.

The Eco-SSL approach calculated the geometric mean NOAEL of the growth and reproduction effect data to derive a TRV (U.S. EPA 2007a). The U.S. EPA (2007a) examined the geometric mean NOAEL in relationship with the lowest bounded LOAEL for reproduction, growth and survival. If the geometric mean NOAEL was higher than the lowest bounded LOAEL, then the highest bounded NOAEL below the lowest bounded LOAEL was selected as the TRV (U.S. EPA 2007a). In developing the mammal and bird TRVs, the U.S. EPA OSW (1999) gave preference to the lowest chronic or subchronic NOAEL, followed by chronic or subchronic LOAEL. If neither was available, then acute median lethality point estimates or single dose toxicity values were used.

In the second step of the Eco-SSL approach, the U.S. EPA back-calculated the Eco-SSLs (soil concentrations) for three surrogate mammalian or avian species based on the TRV derived in the first step and a wildlife exposure model. For the SLWRA, the lowest Eco-SSL provided of the three surrogate species was selected.

A summary of COPCs included in the Soil Quality Guidelines Protective of Wildlife is provided in Table 9.

Table 9 Soil Quality Guidelines Protective of Wildlife

Chemical of Potential Concern	Soil Quality Guideline [mg/kg]		Reference
	Mammalian	Avian	
Aliphatic C_2-C_8 group	11,000	–	AENV 2007
Aliphatic C_9-C_{16} group	9,800	–	AENV 2007
Aliphatic C_{17}-C_{34} group	16,000	–	AENV 2007
Aromatic C_9-C_{16} group	9,800	–	AENV 2007
Arsenic	46	43	U.S. EPA 2005a
Barium	2,000	–	U.S. EPA 2005b
Beryllium	21	–	U.S. EPA 2005c
Cadmium	0.36	0.77	U.S. EPA 2005d
Chromium	34	26	U.S. EPA 2005e
Cobalt	230	120	U.S. EPA 2005f
Copper	49	28	U.S. EPA 2007b
HMW PAH group	1.1	–	U.S. EPA 2007c
Lead	56	11	U.S. EPA 2005h
LMW PAH group	100	–	U.S. EPA 2007c
Manganese	4,000	4,300	U.S. EPA 2007d
Mercury	–	–	–
Molybdenum	–	–	–
Naphthalene group	2.1	–	AENV 2007
Nickel	130	210	U.S. EPA 2007e
Selenium	4.5	–	CCME 2006
Vanadium	280	7.8	U.S. EPA 2005h
Zinc	640	–	CCME 2006

[a] Mammalian SQG were not available for mercury and molybdenum.

[b] Avian SQG were not available for barium, beryllium, chromium VI, Fluorenes, mercury, molybdenum, naphthalene group, pyrenes, selenium and zinc, or, in the case of methyl mercury, will not be emitted into the air by the Project. Based on surface soil guideline values protective of wildlife soil and food ingestion for natural area land use.

– = No guideline available.

3.4.4 Risk Characterization

The risk characterization step of the SLWRA involved comparing:

- predicted air concentrations for each of the assessment cases (i.e., EAC, Project Case and PDC) to wildlife TRVs; and
- predicted soil concentrations for each of the assessment cases (i.e., EAC, Project Case and PDC) to SQGs.

Hazard Quotients (HQs) were calculated by dividing the predicted contaminant concentration in air or soil by the available TRV or SQG, as indicated in the following equations:

$$\text{Inhalation HQ} = \frac{\text{Predicted Air Concentration } (\mu g/m^3)}{\text{TRV } (\mu g/m^3)}$$

or

$$\text{Oral HQ} = \frac{\text{Predicted Soil Concentration (mg/kg)}}{\text{SQG (mg/kg)}}$$

Interpretation of the HQ values proceeded as follows:

- HQ ≤1 indicates that the estimated total exposure is less than the TRV or SQG. This suggests that risks to wildlife are considered negligible for the COPC.
- HQ >1 indicates that the estimated total exposure is greater than the TRV or SQG. This suggests that an elevated level of risk may exist, the significance of which must be balanced against the high degree of conservatism incorporated in the SLWRA. Following careful review of the assumptions incorporated into the SLWRA, decisions will need to be made whether or not additional, more detailed work is warranted.

Hazard quotients based on inhalation for the three assessment cases are provided in Table 10 and 11 on an acute bases, and Table 12 and 13 on a chronic basis. The predicted HQs for oral exposure are provided in Tables 14 and 15 for those COPCs that “exceeded” chemical fate and persistence screening criteria.

4 ASSESSMENT CASES

Separate assessments were completed for acute and chronic exposures because the potential health effects produced by each COPC will depend on the duration of exposure.

In the chronic assessment, further distinction was made between inhalation and oral exposures since some of the COPCs can remain persistent and accumulate in the environment, while other COPCs are highly volatile and will remain in the atmosphere.

In recognition of the influence of duration and pathway of exposure, risk estimates were segregated into:

- acute inhalation;
- chronic inhalation; and
- chronic oral pathway.

The acute and chronic risk estimates are presented in scientific notation as many of the calculated numerical values were well below 1. For instance, the acute risk estimate for mammalian wildlife exposed to the maximum aliphatic C_2-C_8 group air concentration under the EAC is 4.0E-06, which is equivalent to a HQ of 0.0000040 (Table 10).

4.1 ACUTE INHALATION ASSESSMENT

Acute inhalation risk estimates, expressed as Hazard Quotients (HQs), are based on an assumed exposure period that lasts an hour. The maximum HQ values are provided in Tables 11 and 12 for the mammalian and avian wildlife receptors, respectively.

Predicted acute HQ values do not exceed 1 under any of the three assessment cases (i.e., EAC, Project Case and PDC) for mammalian and avian wildlife receptors, indicating that short-term air concentrations are not anticipated to have an adverse effect on either avian or mammalian wildlife in the region.

Table 10 Acute Inhalation Hazard Quotients – Mammalian Receptor

Chemical of Potential Concern[a]	Averaging Time	Hazard Quotient[b][c]		
		Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1-hour	4.0E-06	4.9E-06	5.3E-06
Aliphatic C_9-C_{16} group	1-hour	5.3E-06	5.6E-06	6.8E-06
Aromatic C_9-C_{16} group	1-hour	3.8E-06	3.8E-06	4.8E-06
Arsenic	1-hour	3.9E-09	1.1E-08	1.1E-08
Benzene	1-hour	9.4E-08	9.4E-08	9.4E-08
Beryllium	1-hour	1.6E-07	4.3E-07	4.3E-07
Cadmium	1-hour	7.6E-08	2.1E-07	2.1E-07
Carbon disulphide group	1-hour	7.1E-07	1.0E-06	1.0E-06
Carbon monoxide	1-hour	1.9E-04	2.2E-04	2.2E-04
Chromium	1-hour	8.9E-08	2.4E-07	2.4E-07
Cobalt	1-hour	1.3E-09	2.9E-09	2.9E-09
Copper	1-hour	1.3E-09	3.5E-09	3.5E-09
Ethylbenzene	1-hour	8.6E-08	8.6E-08	1.0E-07
Formaldehyde	1-hour	4.3E-06	4.3E-06	4.3E-06
Hexane group	1-hour	5.3E-08	5.3E-08	6.6E-08
Hydrogen sulphide	1-hour	6.4E-06	9.1E-06	9.1E-06
Manganese	1-hour	1.3E-08	3.4E-08	3.4E-08
Mercury	1-hour	1.7E-08	4.8E-08	4.8E-08
Methyl ethyl ketone group	1-hour	3.0E-08	3.0E-08	3.0E-08
Molybdenum	1-hour	3.7E-10	1.0E-09	1.0E-09
Naphthalene group	1-hour	4.4E-07	4.4E-07	4.4E-07
Nickel	1-hour	6.4E-08	1.7E-07	1.7E-07
Nitrogen dioxide	1-hour	1.5E-03	2.8E-03	2.8E-03
Selenium	1-hour	2.0E-08	2.0E-08	2.0E-08
Sulphur dioxide	1-hour	1.1E-04	1.6E-04	1.6E-04
Toluene	1-hour	2.6E-08	2.6E-08	3.5E-08
Trimethylbenzenes	1-hour	1.5E-08	1.5E-08	2.0E-08
Vanadium	1-hour	8.7E-08	1.9E-07	1.9E-07
Xylenes	1-hour	1.9E-07	1.9E-07	2.4E-07
Zinc	1-hour	2.9E-08	7.9E-08	7.9E-08

[a] Aliphatic C_{17}-C_{34} group, barium, ethylene, HMW PAH group, lead, and LMW PAH group were not included in the inhalation assessment due to the lack of adequate acute inhalation toxicity data for mammals.

[b] An HQ equal to or less than 1 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

[c] The maximum predicted HQ value for all discrete receptor locations identified in the HHRA is presented for each assessment case.

Table 11 Acute Inhalation Hazard Quotients – Avian Receptor

Chemical of Potential Concern[(a)]	Averaging Time	Hazard Quotient[(b)(c)]		
		Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1-hour	1.2E-05	1.4E-05	1.5E-05
Carbon monoxide	1-hour	2.6E-04	3.1E-04	3.1E-04
Hexane group	1-hour	2.5E-06	2.5E-06	3.2E-06
Sulphur dioxide	1-hour	1.1E-04	1.6E-04	1.6E-04

(a) The remaining COPCs were not included in the inhalation assessment due to the lack of adequate acute inhalation toxicity data for birds.

(b) An HQ equal to or less than 1 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) The maximum predicted HQ value for all discrete receptor locations identified in the HHRA is presented for each assessment case.

4.2 CHRONIC INHALATION ASSESSMENT

Chronic inhalation risk estimates, expressed as HQs, are based on exposure periods that last from a few months to a few years, to possibly a lifetime. The maximum of the HQ values predicted at all the receptor locations used in the HHRA are provided in Tables 12 and 13 for mammalian and avian wildlife receptors, respectively.

Predicted chronic HQ values do not exceed 1 under any of the three assessment cases (i.e., EAC, Project Case and PDC) for mammalian and avian wildlife receptors, indicating that long-term air concentrations are not anticipated to have an adverse impact on either avian or mammalian wildlife in the region.

Table 12 Chronic Inhalation Hazard Quotients – Mammalian Receptor

Chemical of Potential Concern[(a)]	Hazard Quotient[(b)(c)]		
	Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	2.1E-06	2.1E-06	2.4E-06
Aliphatic C_9-C_{16} group	3.6E-05	3.6E-05	4.1E-05
Aromatic C_9-C_{16} group	8.7E-07	8.7E-07	1.0E-06
Arsenic	1.1E-08	1.8E-08	1.9E-08
Barium	4.1E-06	6.8E-06	7.3E-06
Benzene	1.8E-05	1.8E-05	1.8E-05
Beryllium	3.4E-08	5.6E-08	5.9E-08
Cadmium	4.1E-04	6.5E-04	7.1E-04
Carbon disulphide group	9.7E-07	1.8E-06	1.8E-06
Chromium	1.9E-06	2.9E-06	3.1E-06
Cobalt	7.0E-06	9.9E-06	1.1E-05

Table 12 Chronic Inhalation Hazard Quotients – Mammalian Receptor (continued)

Chemical of Potential Concern[(a)]	Hazard Quotient[(b)(c)]		
	Existing and Approved Case	Project Case	Planned Development Case
Copper	3.7E-07	6.0E-07	6.4E-07
Ethylbenzene	4.1E-07	4.1E-07	5.0E-07
Ethylene	1.7E-06	1.7E-06	1.7E-06
Formaldehyde	4.8E-04	4.8E-04	4.9E-04
Hexane group	4.7E-07	6.2E-07	7.4E-07
Hydrogen sulphide	3.4E-05	6.3E-05	6.4E-05
Manganese	4.7E-07	7.1E-07	7.5E-07
Mercury	2.7E-07	4.4E-07	4.7E-07
Methyl ethyl ketone group	2.1E-07	2.1E-07	2.2E-07
Molybdenum	1.2E-08	1.9E-08	2.0E-08
Naphthalene group	1.0E-06	1.1E-06	1.1E-06
Nickel	1.6E-05	2.3E-05	2.5E-05
Nitrogen dioxide	1.5E-01	2.0E-01	2.4E-01
Sulphur dioxide	2.5E-03	6.0E-03	6.0E-03
Toluene	3.9E-05	3.9E-05	4.5E-05
Trimethylbenzenes	4.9E-08	4.9E-08	6.6E-08
Vanadium	3.9E-05	5.6E-05	6.3E-05
Xylenes	1.1E-05	1.1E-05	1.3E-05

(a) Aliphatic C_{17}-C_{34} group, carbon monoxide, HMW PAH group, lead, LMW PAH group, selenium and zinc were not included in the inhalation assessment due to the lack of adequate chronic inhalation toxicity data for mammals.

(b) An HQ equal to or less than 1 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) The maximum predicted HQ value for all discrete receptor locations identified in the HHRA is presented for each assessment case.

Table 13 Chronic Inhalation Hazard Quotients – Avian Receptor

Chemical of Potential Concern[(a)]	Hazard Quotient[(b)(c)]		
	Existing and Approved Case	Existing and Approved Case	Existing and Approved Case
Aliphatic C_2-C_8 group	1.1E-04	1.1E-04	1.2E-04
Hexane group	7.7E-06	1.0E-05	1.2E-05

(a) The remaining COPCs were not included in the inhalation assessment due to the lack of adequate chronic inhalation toxicity data for birds.

(b) An HQ equal to or less than 1 signifies that the estimated exposure is equal to or less than the exposure limit and no health effects are expected. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that predicted exposures were less than the exposure limit; whereas, a value expressed to the positive power (i.e., E+x) shows exposure estimates exceeded the exposure limit.

(c) The maximum predicted HQ value for all discrete receptor locations identified in the HHRA is presented for each assessment case.

4.3 CHRONIC ORAL PATHWAY ASSESSMENT

Chronic risk estimates associated with oral exposure, expressed as HQs, were calculated for those COPCs that could persist or accumulate in the environment. The maximum HQ values are provided in Tables 14 and 15 for the mammalian and avian wildlife receptors, respectively.

Predicted chronic HQ values do not exceed 1 under any of the three assessment cases (i.e., EAC, Project Case and PDC) for mammalian and avian wildlife receptors, indicating that long-term soil concentrations are not anticipated to have an adverse impact on either avian or mammalian wildlife in the region.

Table 14 Hazard Quotients in Relation to Soil Quality Guidelines – Mammalian Receptor

Chemical of Potential Concern[(a)]	Hazard Quotient[(b)]		
	Existing and Approved Case	Project Case	Planned Development Case
Aliphatic C_2-C_8 group	1.5E-10	1.5E-10	1.6E-10
Aliphatic C_9-C_{16} group	1.2E-08	1.2E-08	1.4E-08
Aliphatic C_{17}-C_{34} group	3.1E-08	3.1E-08	3.1E-08
Aromatic C_9-C_{16} group	2.5E-08	2.5E-08	3.0E-08
Arsenic	1.4E-02	1.4E-02	1.4E-02
Barium	9.4E-03	9.5E-03	9.5E-03
Beryllium	6.4E-03	6.5E-03	6.5E-03
Cadmium	5.1E-01	5.6E-01	5.7E-01
Chromium	8.6E-02	8.6E-02	8.6E-02
Cobalt	5.7E-03	5.8E-03	5.8E-03
Copper	6.5E-02	6.5E-02	6.5E-02
HMW PAH group	4.9E-03	4.9E-03	5.0E-03
Lead	4.1E-02	4.1E-02	4.1E-02
LMW PAH group	4.4E-07	4.4E-07	4.5E-07
Manganese	1.6E-02	1.6E-02	1.6E-02
Naphthalene group	2.8E-06	2.8E-06	2.8E-06
Nickel	2.4E-02	2.4E-02	2.4E-02
Selenium	1.0E-01	1.0E-01	1.0E-01
Vanadium	2.2E-02	2.2E-02	2.2E-02
Zinc	2.0E-02	2.0E-02	2.0E-02

(a) Mercury and molybdenum were not included in the oral exposure pathway assessment due to the lack of SQGs for mammals.

(b) An HQ equal to or less than 1 signifies that the soil concentration is equal to or less than the SQG and no health effects are expected. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that soil concentrations were less than the SQG; whereas, a value expressed to the positive power (i.e., E+x) shows soil concentrations exceeded the SQG.

Table 15 Hazard Quotients in Relation to Soil Quality Guidelines – Avian Receptor

Chemical of Potential Concern[a]	**Hazard Quotient**[b]		
	Existing and Approved Case	**Project Case**	**Existing and Approved Case**
Arsenic	1.5E-02	1.5E-02	1.5E-02
Cadmium	2.4E-01	2.6E-01	2.7E-01
Chromium	1.1E-01	1.1E-01	1.1E-01
Cobalt	1.1E-02	1.1E-02	1.1E-02
Copper	1.1E-01	1.1E-01	1.1E-01
Lead	2.1E-01	2.1E-01	2.1E-01
Manganese	1.5E-02	1.5E-02	1.5E-02
Nickel	1.5E-02	1.5E-02	1.5E-02
Vanadium	8.0E-01	8.0E-01	8.1E-01

(a) Aliphatic C2-C8 group, aliphatic C9-C16 group, aliphatic C17-C34 group, aromatic C9-C16 group, barium, beryllium, HMW PAH group, LMW PAH group, mercury, molybdenum, naphthalene group, selenium and zinc were not included in the oral exposure pathway assessment due to the lack of SQGs for birds.

(b) An HQ equal to or less than 1 signifies that the soil concentration is equal to or less than the SQG and no health effects are expected. With scientific notation, any value expressed to the negative power (i.e., E-x) shows that soil concentrations were less than the SQG; whereas, a value expressed to the positive power (i.e., E+x) shows soil concentrations exceeded the SQG.

5 CONCLUSIONS

The SLWRA followed a conventional risk assessment paradigm with emphasis placed on the worst-case conditions to ensure risks were not underestimated. The findings and conclusions are based on the conservative assumptions incorporated into the assessment. The major findings and conclusions of the SLWRA are:

- In all instances, the maximum predicted short-term and long-term COPC concentrations in air are below levels at which adverse effects to wildlife populations would be expected via inhalation exposure. Thus, negligible health risks are predicted for wildlife in the air quality study area.
- In all instances, the maximum chronic COPC concentrations in soil are below levels at which adverse effects to wildlife populations would be expected via oral exposure. Thus, negligible health risks are predicted for wildlife in the air quality study area.
- In general, the majority of the potential exposures and associated HQs are dominated by the EAC. That is, there are negligible changes between the EAC and Project Case HQs, signifying low overall contribution of the Project to short-term and long-term wildlife health risks in the region.
- In general, there are negligible changes between the EAC and PDC HQs, signifying low overall contribution of future projects to short-term and long-term wildlife health risks in the region.

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APPENDIX 3-VII

TOXICITY PROFILES

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APPENDIX 3-VIII

MULTIPLE PATHWAY EXPOSURE MODEL

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APPENDIX 3-IX

REGIONAL ENVIRONMENTAL SAMPLING DATA

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APPENDIX 3-X

INHALATION RISK QUOTIENTS

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HEALTH CANADA $PM_{2.5}$

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AIR EMISSIONS EFFECTS SUPPLEMENTAL INFORMATION

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