Impact Analysis of Air Emissions Associated With the Steepbank Mine

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TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

A INTRODUCTION

A1.0 BACKGROUND

Suncor Inc., Oil Sands Group (Suncor) operates an oil sands mining, extraction and bitumen upgrading facility on the west bank of the Athabasca River about 35 km north of Fort McMurray. Suncor operates on two Bitumen Oil Sands Leases (86 and 17), which cover an area of approximately 3900 ha. The facilities are currently approved by the Energy and Utilities Board (EUB) to produce 12.6 thousand m^3/d (79 500 barrels per day) of synthetic crude oil products (EUB Approval 7632).

In the fall of 1994, Suncor announced plans to expand their operations to ensure the company's long-term viability in the Athabasca oil sands area. These plans include:

- A Fixed Plant Expansion Project to increase gross production capacity to 87,000 barrels per day by the year 1998 and to 107,000 barrels per day by the year 2001 (Suncor 1995*a*).
- The Steepbank Mine located on Lease 97 and Lots 1 and 3 which are located on the east side of the Athabasca River. The mine is scheduled to commence operation in the year 2001 (Suncor 1995*b*).

As part of Suncor's Application to obtain approval for the Steepbank Mine, an Environmental Impact Assessment (EIA) has been prepared. This air emissions impact analysis report and associated air quality baseline reports are part of a series of reports that were used to prepare the EIA (Figure A1.0-1).

The objective of the air emissions impact analysis report is to identify and analyze the potential effects associated with the Steepbank Mine and the Fixed Plant Expansion Project. The report provides a summary of existing air quality conditions, along with an analysis of air quality changes. As the Suncor facility is located in an airshed that contains other sources, any regional air quality assessment has to include the combined operation of these other sources, the major one being the Syncrude Canada Ltd. (Syncrude) operation.

A2.0 AIR QUALITY MANAGEMENT

Suncor has approval to operate their facilities under Alberta Environmental Protection and Enhancement Act (AEPEA) Approval No. 92-AL-359I (95) that was originally issued to Suncor as Clean Air Licence-to-Operate (No. 92-AL-359) under the former Clean Air Act. Suncor applied for a renewal of their Environmental Approval in 1995 (Suncor 1995*c*, 1995*d*). The current approval:

- Identifies the emission sources and prescribes the manner by which gases and particulates can be emitted to the atmosphere;
- Identifies the monitoring programs required to ensure the air pollution management system is operating as designed; and
- Identifies the reporting requirements to document and communicate the results of the monitoring program to Alberta Environmental Protection (AEP).

Suncor's air quality management program addresses the AEP requirements specified in the approval and is comprised of the following activities:

- **Source Control Activities.** Suncor's facilities employ design features and management practices to control and reduce potential emissions to the atmosphere. New emission control programs are in progress to further reduce the current emissions.
- **Monitoring Activities.** Source monitoring to identify and quantify emission sources is routinely carried out by Suncor. Suncor has participated in additional ambient air quality monitoring programs to further document spatial and temporal concentration patterns. Suncor will participate in an enhanced receptor monitoring program that will allow

correlations between exposures and receptor effects to be better quantified. This participation is through the Regional Air Quality Coordinating Committee (RAQCC).

- **Airshed Management Activities.** Under the Clean Air Strategy for Alberta (CASA) initiatives, the framework for the air quality management of the Fort McMurray - Fort MacKay airshed is under review.

- **Assessment Activities.** Periodic reviews analyze, summarize and interpret these activities and associated data collection. These assessment activities can be at regular intervals (e.g., annual reports) or intermittent (e.g., environmental assessments).

The air quality impact assessment prepared for Suncor's proposed Fixed Plant Expansion and the Steepbank Mine forms part of the ongoing regional airshed management activities conducted by Suncor.

A3.0 BACKGROUND REPORTS

A series of background air quality reports for the oil sands area provide air quality baseline information to mid-1995:

- **Report 1 Sources of Atmospheric Emissions at the Athabasca Oil Sands Region** Identifies and quantifies anthropogenic air emissions in the Fort McMurray - Fort MacKay corridor which include industrial point, fugitive, traffic and residential sources. Emissions of interest are sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), total hydrocarbons (THC) that include volatile organic compounds (VOC), total reduced sulphur (TRS), particulates (PM) and carbon dioxide (CO_2) (BOVAR Environmental 1996*a*).
- **Report 2 Ambient Air Quality Observations in the Athabasca Oil Sands Region** Summarizes ambient air quality monitoring undertaken in the Fort McMurray - Fort MacKay airshed. The sources include data from the Suncor, Syncrude and Alberta Environmental Protection (AEP) networks, and data associated with other monitoring programs (BOVAR Environmental 1996*b*).

- **Report 3 Meteorology Observations in the Athabasca Oil Sands Region** Summarizes meteorological data which describe the transport, dispersion and deposition of emissions in the area. The focus is on the meteorological data collected by Suncor from the Lower Camp and Mannix towers. A review of the terrain in the region and its effect on meteorology is provided (BOVAR Environmental 1996*c*).
- **Report 4 Ambient Air Quality Predictions for the Athabasca Oil Sands Region** Concurrent source, air quality and meteorological data are used to select a dispersion modelling approach which produces predictions that compare favorably with observations. The modelling complements the ambient monitoring by providing local and regional short and long-term air quality changes associated with the current operations in the area (BOVAR Environmental 1996*d*).

These reports describe the status of current air quality parameters and can be used by industry to assist with future plant or mine applications and by other stakeholders to assist with the review of these applications. Furthermore, these reports can also be used by the Regional Air Quality Coordinating Committee (RAQCC) in support of their regional air quality related initiatives.

A4.0 AIR QUALITY ISSUES

Alberta Environmental Protection (1995) issued a Final Terms of Reference for the Steepbank Mine project. The terms specified for the determination of baseline conditions and corresponding changes to air quality are as follows:

- *"Specify the type, volume and source of air emissions from each component of the integrated operation including fugitive emissions. Identify and describe emission sources at normal operating conditions and during abnormal or upset conditions. Compare the proposed air emissions to the previous air emission levels from the Suncor plant."*
- *"Summarize current emission levels and anticipated regional emission levels of key contaminants, identifying the major point sources of emissions."*

- *"Outline the life-cycle of greenhouse gas emissions for on-site sources and the off-site supply of natural gas electricity."*
- *"Discuss the baseline climatic and air quality conditions. Emphasize those parameters that have the potential to influence the success of mitigation measures and reclamation."*
- *"Characterize the existing air quality and identify air quality parameters of concern. Review current emission sources and anticipated future development scenarios within the Study Area;. Discuss appropriate air quality parameters such as SO_2, H_2S, total hydrocarbons NO_x, VOC's, ground-level ozone, as well as, wind direction, wind speed, temperature, and particulate and acidic deposition patterns. Consider controlled emissions, fugitive air emissions and odours."*

- *"Model regional air quality including consideration of terrain features. Justify the use of selected dispersion model(s) and identify any short-comings of the models or constraints to their findings. Address both local and regional effects and assess their implications."*
- *"Identify the activities that will affect air quality. Evaluate the impacts to air quality as a result of the proposed project. Identify a program to monitor air quality during construction and operation of the Steepbank Mine Project in order to assess current and future emissions from the Suncor operation. Discuss the need for changes to current monitoring programs including biomonitoring and ambient air monitoring. Discuss Suncor's anticipated role in any zonal air monitoring in the Study Area."*
- *"Comment on the impact of Suncor's emissions on provincial and federal commitments regarding greenhouse gases."*

Key air quality related issues from the multistakeholder workshops are identified in Table A4.0-1. Some of these issues are addressed directly in this report; namely:

- Greenhouse Gas Emissions (Issues 1 and 2).
- Fugitive Dust Emissions (Issues 3, 4 and 5).
- Fugitive Hydrocarbon Emissions (Issues 6, 7 and 8).
- Combustion Particulate Emissions (Issue 16).
- Regional Emission Sources (Issue 14).

- Abnormal Emissions (Issue 13).

The consequences of air emissions on exposed receptors are addressed in the other Suncor environmental impact analysis reports and include:

- Wildlife Health (Issues 9 and 11): Impact Analysis Suncor Steepbank Mine Environmental Wildlife Component (Westworth, Brusnyk & Associates, 1996)
- Aquatic Effects (Issue 10): Impact Analysis of Terrestrial Issues Associated with the Steepbank Mine (Golder, 1996a)
- Vegetation Effects (Issue 12): Impact Analysis of Terrestrial Resources Associated with the Steepbank Mine (Golder, 1996a)
- Human Health (Issue 15): Impact Analysis of Human Health Issues Associated with the Steepbank Mine (Golder, 1996b)

Current and expected air quality changes associated with Suncor's current and proposed operations (both the Fixed Plant Expansion Project and the Steepbank Mine) are provided in this assessment. The air quality impact analysis focuses on determining changes to the chemical composition of the air and not on the effect these changes may have on receptors. Effects of air quality changes to forest ecosystems and human health are discussed in the Terrestrial Resources Impact Analysis and the Human Health Impact Analysis reports, respectively. These reports are identified in Figure A1.0-1.

The concern with respect to the potential for Suncor's emissions to contribute to global climate changes was stated as an Impact Hypothesis. This hypothesis (number 35) is stated, along with the hypotheses for the other reports in this series, in Table A4.0-2.

TABLE A4.0-1
STAKEHOLDER ISSUES REGARDING AIR QUALITY

NUMBER	ISSUE	SECTION DISCUSSED
1	Is CH_4 included in greenhouse gas review?	B1.1-2, C3.0, D2.9
2	Global climate change - what about greenhouse gas emissions?	C3.0, D2.9
3	Will there be impacts from fugitive dust from coke piles, overburden dumps and tailings ponds?	D2.3
4	Will there be gypsum dusting problems?	D2.3
5	Will there be impacts from greater sulphur stockpiling?	D2.3
6	What are the emissions from the hydrotransport building?	C1.3, D2.1
7	Are there additional gas emissions from treatment wetlands?	C1.4, D2.1
8	What will be the effects of VOC and THC fugitive emissions?	B4.5, B5.7, C2.6, D2.7, D2.8-6
9	Will there be impacts to wildlife health from air emissions?	(a)
10	What are the potential effects on off-site water bodies from the atmospheric release of combustion products (PAHs, dioxins)?	(b)
11	Will there be effects on lichen health for caribou habitat in Thickwood Hills, Muskeg Mountain from air emissions?	Figures B5.0-1 to B5.0-3, Figures C2.0-4 to C2.0-7, (b)
12	Will there be air emission effects (i.e., acidification) to regional vegetation?	B5.3, C2.3, C2.4, D2.8.2, Figures B5.0-5, B5.0-6, C2.0-9, C2.0-10, (b)
13	What will be the stack emissions including SO_2, NO_x and VOC from operational flaring?	B1.1.2, D2.1
14	Are you considering cumulative effects from the past? from beehive burners and future (Syncrude, Solv-Ex, Fording Coal, AlPac, etc.)?	B1.3, D2.2
15	Will air studies be tied into human health?	E3.0, (c)
16	Will particulates and heavy metals be addressed (e.g., NH_4 $(NH_4)_2$ SO_4 $(SO_3)_2$)?	D2.4

(a) Impact Analysis Suncor Steepbank Mine Environmental Wildlife Component.
(b) Impact Analysis of Terrestrial Resources Associated with the Steepbank Mine.
(c) Impact Analysis of Human Health Issues Associated with the Steepbank Mine.

TABLE A4.0-2
STEEPBANK MINE EIA IMPACT HYPOTHESIS SUMMARY LIST

SOCIO-ECONOMIC	
1	The Steepbank Mine Project will contribute additional local, provincial and national benefits through additional employment, the procurement of goods and services required for the project and the payment of local, provincial and national taxes and royalties.
2	Construction-related activities and employment and the associated temporary increase in population will result in increased demands on services and infrastructure within the Regional Municipality of Wood Buffalo.
3	Operations-related employment and the associated increase in population will result in increased demands on services and infrastructure within communities in the Regional Municipality of Wood Buffalo.
4	The social stability and quality of life of communities within Regional Municipality of Wood Buffalo will be maintained as a result of the continued operation of the Suncor project, through development of the Steepbank Mine.
5	The Steepbank Mine project will contribute to a loss in the traditional resource base of the Fort MacKay community and displace some traditional activities.
6	The cumulative demands from the Suncor, Solv-Ex and Syncrude projects combined with the expected demands from existing populations within the Regional Municipality of Wood Buffalo will result in increased demands on local communities and affect the quality of life of those communities.
HUMAN HEALTH	
7	The health and well being of people who live, work or engage in recreational activities within the study area may be affected by changes to Athabasca and Steepbank River water quality caused by water releases resulting from extraction, processing and reclamation of oil sands from Suncor's existing and proposed mines.
8	The health and well being of people who live, work or engage in recreational activities within the study area may be affected by air emissions resulting from extraction, processing and reclamation of oils sands from Suncor's existing or proposed mines.
9	The health and well being of people who live, work or engage in recreational activities within the study area may be affected by cumulative exposure to chemicals associated with water and air emissions from Suncor's activities and other developments within the Regional Study Area.
10	The health of people who in the future may occupy and/or use the land reclaimed from Suncor's Lease 86/17 and Steepbank Mine may be affected by release of chemicals from the reclaimed landscapes.
11	The health and safety of on-site workers may be affected by development and operations of the Steepbank Mine and related facilities.
TERRESTRIAL	
12	Valued Ecosystem Components in the Athabasca River valley could be affected by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
13	Existing and future use of the area's landscapes could be limited by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
14	Visual integrity of the Athabasca River Valley could be affected by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
15	Biodiversity could be affected by the development, operation and reclamation of the Steepbank Mine and Lease 86/17.
16	Wetlands could be affected by Lease 86/17 and Steepbank Mine development and operation, including mine dewatering, changes to subsurface drainage, and reclamation release water.
17	Air emissions from the Suncor operation could have an impact on vegetation and soils, as well as aquatic environments.

WILDLIFE	
18	Mine development will result in changes in the availability and quality of wildlife habitat which will bring about a reduction in wildlife populations
19	Disturbance associated with mechanical noise and human activity may result in reduced abundance of wildlife.
20	Direct mortality of wildlife caused by mine development could result in reduced abundance of wildlife.
21	Mine development will disrupt the movement patterns of wildlife in the vicinity of the Steepbank Mine, thereby reducing access to important habitat or interfering with population mechanisms, resulting in decreased abundance of wildlife.
22	Mine development could cause a reduction in wildlife resource use (hunting, trapping, non-consumption recreational use).
23	Development of the Steepbank Mine could contribute to a loss of natural biodiversity.
SURFACE AND GROUNDWATER RESOURCES	
24	Flows in the Athabasca and Steepbank Rivers could be significantly changed by mine development withdrawals for extraction, upgrading and/or reclamation.
25	Ice jams, floods or other hydrological events could cause structure damage and flooding of facilities that will result in subsequent impacts to hydrological/aquatic systems and downstream uses.
26	Navigation along the Athabasca River could be affected by bridge construction.
27	Groundwater quality could be affected by contaminant migration from processing and extraction activities.
AQUATIC RESOURCES	
28	Construction, operational or reclamation activities might adversely affect aquatic habitat in the Steepbank River.
29	Construction, operational or reclamation activities might adversely affect aquatic habitat in the Athabasca River.
30	Water releases associated with construction, operational or reclamation activities might adversely affect aquatic ecosystem health in the Athabasca or Steepbank Rivers.
31	Water releases associated with construction, operational or reclamation activities might adversely affect the quality of fish flesh.
32	Construction, operational or reclamation activities might lead to changes in aquatic habitat and/or aquatic health which might result in a decline in fish abundance in the Athabasca or Steepbank Rivers.
33	Construction, operational or reclamation activities might lead to changes in fish abundance or quality of fish flesh which might result in a decreased use of the fish resource.
34	Construction, operational or reclamation activities might cause changes in Athabasca River water quality which limit downstream use of the water.
AIR QUALITY	
35	Global climate change could be affected by increased release of greenhouse gases associated with production expansion related to the Steepbank Mine.
HISTORICAL RESOURCES	
36	Significant archaeological, paleontological or historical resources could be affected by the development and operation of the Steepbank Mine.

A5.0 IMPACT ASSESSMENT APPROACH

This air emission impact analysis report uses the background reports to define current conditions and provides an evaluation of changes in air quality that could be associated with the proposed Fixed Plant Expansion and Steepbank Mine. The information presented in this assessment and the format is based on the expectations for the air quality portion of an EIA defined by Alberta Environmental Protection (1994) draft guidelines. Section B of this report describes existing conditions and includes the following:

- Identification of **emissions** associated with current (1995) operation scenarios.
- Description of **topography** in the vicinity of the oil sands operations.
- Summary of **meteorological observations** collected in the area.
- Discussion of **current ambient air quality** in the region based on monitoring data collected since 1990.
- Dispersion **model predictions** of ambient concentrations associated with current operations.

Section C of this report defines air quality changes and includes the following:

- Identification of **changes in emissions** with the proposed operation scenarios.
- **Dispersion model predictions** of ambient concentrations associated with the proposed operation.
- Discussion of **greenhouse gas** emissions.

The effects associated with the proposed emission scenarios address two primary time periods:

- 1998 corresponds to the Stage 1 of the Fixed Plant Expansion and to the Steepbank Mine Construction period (1997 to 2000).
- 2001 corresponds to the Stage 2 Fixed Plant Expansion and to the operation of the Steepbank Mine (2001 to 2020).

The air quality analysis focuses on the Fixed Plant changes because the air quality emissions that have off-site effects tend to result more from Suncor's Fixed Plant Operations rather than from the mine itself.

Section D of this report provides an air quality impact analysis while Section E describes recommended monitoring programs. Section F identifies references and Section G provides a glossary of acronyms, units, symbols and terms applicable to the air emissions impact analysis.

A6.0 STUDY AREA BOUNDARIES

The study area for the Steepbank Mine EIA is defined by both a Local Study Area and a Regional Study Area. The former is delineated by the Lease and Lot boundaries which comprise the Steepbank Mine development project as well as the existing development in Lease 86/17. The Regional Study Area was based on airshed, watershed and ecological criteria. For the air quality impact assessment, the main focus is on the Regional Study Area as identified in Figure A6.0-1. In delineating the airshed, previous air quality assessments indicated an airshed to be defined by a 60 km radius around the sources.

B EXISTING AIR QUALITY SUMMARY

B1.0 CURRENT EMISSIONS

The operation of oil sands mining, extraction and upgrading facilities in the Athabasca oil sands region results in gaseous and particulate emissions from controlled and fugitive sources. Additional emissions to the airshed result from other sources, including other industrial operations, transportation and community sources.

B1.1 CURRENT SUNCOR EMISSIONS

B1.1.1 Source Identification

Table B1.0-1 identifies the emission sources and associated emissions for Suncor's current operations. The sources have been categorized according to Suncor's operating units: mining, extraction, upgrading and utilities. The sources can also be categorized as:

- Continuous combustion sources include the Powerhouse stack that services three coke-fired boilers; Incinerator stack that services the sulphur recovery plant; upgrading secondary stacks that are either natural gas or refinery gas-fired; and exhaust gases from the mine fleet that use diesel fuel.
- Intermittent combustion sources include two hydrocarbon flares, one acid gas flare and a hydrogen plant flare that are used for plant start-up, shut-down and upset conditions. The flare stacks are serviced by continuous pilots and are used for both planned and unplanned disposal of gas streams.
- Plant vents that service various storage tanks, process vessels and buildings. The vent gases typically contain hydrocarbon product which may also include reduced sulphur compounds.

- Fugitive particulate emissions result from surface disturbances that include mining activities, traffic, storage piles (e.g., coke) and tailings pond dykes.
- Fugitive hydrocarbon emissions result from leaks in the upgrading area (i.e., valves, flanges, piping, rotating seals, drains) and from area sources (mine surfaces and tailings ponds).

The current operations employ a number of emission reduction practices. The major practices can be summarized as:

- An electrostatic precipitator removes 98% of particulate matter from flue gases generated during coke combustion in the utilities plant.
- A Supplemental Emission Control system reduces Powerhouse stack SO_2 emissions when ambient concentrations at the monitoring trailers exceed guidelines.
- A SuperClaus sulphur recovery plant removes 98% of the sulphur in the acid gas prior to venting through the Incinerator stack.
- Improved operating procedures and equipment reliability has reduced the frequency of intermittent flaring.
- A Naphtha Recovery Unit (NRU) recovers light hydrocarbons from Extraction Plant 4 tailings prior to discharge to Tailings Pond 1.
- A Vapour Recovery Unit (VRU) recovers about 99% of the hydrocarbon and TRS emission from Plant 4 vents, the NRU and the south tank farm vents.
- A sour water stripping system is used to strip H_2S from process water that becomes contaminated with H_2S. The stripped H_2S is routed to the sulphur plant.
- Mine haul roads are sprayed with water to reduce fugitive dust emissions on dry, windy days.
- Tailings pond dykes are revegetated on the exterior slopes to reduce wind blown sand.

TABLE B1.0-1
SOURCES OF GASEOUS AND PARTICULATE EMISSIONS FROM SUNCOR'S CURRENT OPERATION

SOURCE	EMISSION							
	SO_2	NO_x	CO_2	CO	THC/VOC	PM_c	PM_s	TRS/H_2S
Mining								
Mine surfaces					✓		✓	
Mine equipment							✓	
Mine equipment exhausts	✓	✓	✓	✓	✓	✓		
Extraction								
Extraction plant 3 (Primary)					✓			✓
Extraction plant 4 (Secondary)					✓			✓
Naphtha Recovery Unit					✓			✓
Vapour Recovery Unit					✓			✓
South Tank farm vents					✓			
Tailings pond 1 (Plant 4 discharge)					✓		✓	✓
Tailings pond 1A					✓		✓	
Tailings pond 2/3 (Plant 3 discharge)					✓		✓	
Tailings pond 4 (Plant 4 discharge)					✓		✓	
Upgrading								
Incinerator stack	✓	✓	✓	✓		✓		✓
Secondary combustion stacks (19)	✓	✓	✓	✓	✓	✓		
Hydrocarbon flares (2)	✓	✓	✓	✓	✓			
Acid gas flare	✓		✓					
Hydrogen flare		✓	✓	✓				
North Tank farm vents					✓			
Vents					✓			✓
Fugitive emissions					✓			✓
Sulphur storage							✓	

SOURCE	EMISSION							
	SO_2	NO_x	CO_2	CO	THC/VOC	PM_c	PM_s	TRS/H_2S
Utilities								
Powerhouse stack	✓	✓	✓	✓	✓	✓		
Coke storage	✓		✓	✓		✓	✓	

SO_2 = sulphur dioxide
NO_x = oxides of nitrogen
CO_2 = carbon dioxide
CO = carbon monoxide
THC = total hydrocarbon
VOC = volatile organic compounds
PM_c = particulate matter from combustion sources
PM_s = particulate matter from fugitive surface sources
TRS = total reduced sulphur
H_2S = hydrogen sulphide

B1.1.2 Suncor Emission Quantification

BOVAR Environmental reviewed the information and data obtained from Suncor to determine emissions associated with the Suncor operations. Suncor also conducted a review of their emissions. While the BOVAR Environmental and Suncor results are not completely independent, the differences between the results do provide an indication of the uncertainty of using different approaches to estimate emissions from a complex industrial facility such as Suncor's.

Table B1.0-2 provides a summary of the emissions and the respective emission rates corresponding to Suncor's current operations. The THC/VOC emissions are based on estimates prior to the VRU becoming operational. When fully operational, the THC/VOC emissions are expected to be in the 17 to 23 t/d range. No estimates for surface generated particulate matter (PM_s) have been provided. The information in Table B1.0-2 is based on the BOVAR Environmental and Suncor estimates which are provided in additional detail in Tables B1.0-3 to B1.0-9.

TABLE B1.0-2
CURRENT SUNCOR EMISSIONS

EMISSION	EMISSION RATE (t/cd)
SO_2	234 to 238
NO_x	24 to 37
CO_2	9643 to 9677
CO	21
PM_c	7
THC/VOC	35 to 42
TRS/H_2S	1

TABLE B1.0-3
SO_2 EMISSIONS ASSOCIATED WITH CURRENT SUNCOR OPERATIONS

SOURCE	SO_2 (t/cd)	
	BOVAR (1994)	SUNCOR (1995)
Powerhouse	211 to 213	215
Incinerator	17[a]	19[b]
Secondary Combustion Sources	2.5	
Intermittent Flaring	5.0	
Continuous Flaring	2.3	
Mine Fleet Vehicles	0.3	-
Total	238	234

(a) 1995 value.
(b) Estimated total for Incinerator, secondary sources, intermittent flaring and continuous flaring.

The major sources of SO_2 emissions are the Powerhouse (~ 214 t/d), Incinerator (~ 17 t/d) and flaring (~ 7 t/d). It should be noted that the above values are expressed on a calendar day basis and that during any given day, the actual values could be much larger. This is particularly true for intermittent flaring when more than 50 t of SO_2 per event can occur. On average, in 1994, 1816 t of SO_2 were emitted during 1458 hours of flaring resulting in an average emission rate of 1.2 t/h which is equivalent to an emission rate of 30 t/d.

TABLE B1.0-4
NO_x EMISSIONS ASSOCIATED WITH CURRENT SUNCOR OPERATIONS

SOURCE	NO_x (t/cd)	
	BOVAR (1994)	SUNCOR (1995)
Powerhouse	16.4	20.81
Incinerator	0.11	
Secondary Combustion Sources	4.12	
Intermittent Flaring	0.01	13.18[a]
Continuous Flaring	-	
Mine Fleet	3.06	3.09
Total	23.7	37.08

[a] Estimated total for Incinerator, secondary sources, intermittent flaring and continuous flaring.

The main difference appears to be associated with sources in the upgrading area. The BOVAR total of 4.24 t/d is based on NO_x emission factors that range from 43 to 85 ng/J which were based on U.S. EPA emission factors. The Suncor emission factors for NO_x range from 86 ng/J to 300 ng/J. Larger emission factors will result in higher NO_x emission estimates.

These CO_2 emissions include those associated with the electrical power imported by Suncor. Suncor imported about 10 MW in 1995; in Alberta this power is generated through the combustion of coal. With an emission factor of 1016 kg/MW·h; this amount corresponds to 248 t/cd of CO_2 equivalent.

TABLE B1.0-5
CO_2 EMISSIONS ASSOCIATED WITH CURRENT SUNCOR OPERATIONS

SOURCE	CO_2 (t/cd)	
	BOVAR (1994)	SUNCOR (1995)
Powerhouse	5665	6124
Incinerator	92.5[a]	3063
Secondary Combustion Sources	3451	
Intermittent Flaring	19.5	
Continuous Flaring	-	
Mine Fleet	201	208
External Electrical Power	248	248
Total	9677	9643

(a) 1995 value.

TABLE B1.0-6
CO EMISSIONS ASSOCIATED WITH CURRENT SUNCOR OPERATIONS

SOURCE	CO (t/cd)
Powerhouse	14.1
Incinerator	5.5
Secondary Combustion Sources	0.85
Intermittent Flaring	0.055
Continuous Flaring	0.038
Mine Fleet	0.89
Total	21.4

Suncor did not calculate CO emissions. The CO emissions provided by BOVAR are based on emission factors. CO emissions are relatively small when compared to NO_x or SO_2 emissions.

TABLE B1.0-7
PARTICULATE MATTER (PM_C) EMISSIONS ASSOCIATED WITH CURRENT SUNCOR OPERATIONS (COMBUSTION SOURCES ONLY)

SOURCE	PARTICULATES (t/cd)
Powerhouse	6.3
Incinerator	0
Secondary Combustion Sources	0.27
Intermittent Flaring	-
Continuous Flaring	-
Mine Fleet	0.18
Total	6.75

The Powerhouse emissions are based on measurements, while those for the other sources are based on emission factors. The Powerhouse, however, appears to be the major combustion source for particulate emissions.

It should be noted that THC includes methane (CH_4) and non-methane components. The latter is often referred to as VOC (volatile organic compounds). In Table B1.0-8, the emission rates for the combustion sources, extraction plants, tank farms, and other vents were based on U.S. EPA emission factors for THC (i.e., methane and non-methane components). The emission rate for the upgrading facilities was based on a U.S. EPA emission factor for VOC. The emission rate for the tailings ponds was based on measurements. The methane and non-methane (VOC) tailings pond emissions are 40 and 60% of the total, respectively. The methane emissions appear to be much smaller than those associated with CO_2 (Table B1.0-5).

TABLE B1.0-8
HYDROCARBON EMISSIONS INCLUDING VOLATILE ORGANIC COMPOUNDS, ASSOCIATED WITH CURRENT SUNCOR OPERATIONS

SOURCE	BOVAR (t/cd)	SUNCOR (t/cd)
Combustion Sources		
Powerhouse	0	0
Incinerator	0	0
Secondary Stacks	0.04	0
Intermittent Flaring	0.02	0
Continuous Flaring	-	0
Mine Fleet	0.24	0
Other Sources		
Extraction Plant 3	9.87	12.5
Extraction Plant 4	11.45 (0.11)[a]	13.07 (0.027)[a]
South Tank Farm	0.26 to 6.59 (0.066)[a]	6.90 (0.27)[a]
North Tank Farm	0.004 to 0.03	0.04
Other Vents	0.39	-
Upgrading[b]	4.7	6.25
Tailings Ponds	1.78	3.50
Total	35.11 (17.25)[a]	42.26 (22.59)[a]

(a) Values in brackets assume operation of the VRU (vapour recovery unit).
(b) Based on U.S. EPA emission factor for VOC.

The incinerator estimate is based on an assumed maximum TRS content in the flue gas of 300 ppm. This assumption indicates the incinerator could be the largest source of TRS emissions which include hydrogen sulphide (H_2S), carbonyl sulphide (COS) and carbon disulphide (CS_2). The TRS emissions from controlled vents and tailings ponds tend to be in the form of thiophenes.

TABLE B1.0-9
TOTAL REDUCED SULPHUR (TRS) SPECIES EMISSIONS ASSOCIATED WITH CURRENT SUNCOR OPERATIONS

SOURCE	TRS (t/cd)
Incinerator	0.6
Controlled Vents[a]	0.025 to 0.056
Tailings Ponds	0.066
Total	0.7

[a] Plant 4 venting recovered by VRU at 99% efficiency.

B1.2 CURRENT SYNCRUDE EMISSIONS

The other primary source of emissions in the region is Syncrude's Mildred Lake mining, extraction and upgrading operations. Table B1.0-10 provides an overview of their average emissions. The primary source of SO_2 emissions is the main stack and services the CO boiler, the sulphur recovery plant and the sour water stripper. The THC/VOC and TRS emissions are based on updated estimates for the tailings pond (1992) and older estimates (1987) for the plant area. Given recent improvements in the plant operation, THC/VOC and TRS emissions from the plant area are expected to be lower than those given in the table.

B1.3 OTHER INDUSTRIAL SOURCE EMISSIONS

Other existing or approved industrial sources in the Athabasca Oil Sands Region include the following:

- **AOSTRA UTF.** The emission sources at the Alberta Oil Sands Technology and Research Authority (AOSTRA) Underground Test Facility (UTF) include a central utilities flare stack, a glycol heater, a mine heater and five steam generators.

TABLE B1.0-10
CURRENT SYNCRUDE EMISSIONS

EMISSION	1995 EMISSION RATE (t/cd)
SO_2[(a)]	207.4
NO_x[(b)]	31.7
CO_2[(c)]	23,733
CO	54
PM_c	13.9
THC/VOC	17.2
TRS	0.76

- **Solv-Ex Bitumount.** The emission sources at the currently approved SOLV-EX Bitumount facility include the sulphur recovery plant and tail gas incinerator, the sulphuric acid plant, and various secondary sources (i.e., heaters, boilers, dryers and turbines).
- **Solv-Ex Ruth Lake.** The emission sources at the currently approved SOLV-EX Bitumount facility include the acid plant and various secondary sources (i.e., heaters, power boiler and dryers).
- **Northland Forest Products.** The conical waste wood burner at the Northland Forest Products lumber mill.
- **Fort McMurray Hospital.** The hospital incinerator which operates on an intermittent basis.

Table B1.0-11 summarizes and compares the emissions from these industrial sources. The two proposed SOLV-EX facilities are the primary sources of SO_2, NO_x, CO_2, PM_c and THC. The Northlands conical waste wood burner is a primary source of CO, CO_2 and THC. Emissions from these sources, however, are much smaller than those associated with the Suncor and Syncrude operations. The emissions for these sources, unlike the others, are expressed on a "stream day (s/d)", basis instead of a "calendar day (c/d)" basis. This decision was made as we did not have detailed operating data for these sources. Given the magnitude of the associated emissions, the change in presentation format was not viewed as significant.

TABLE B1.0-11
SUMMARY OF EMISSIONS FROM OTHER EXISTING OR APPROVED INDUSTRIAL SOURCES

EMISSION (t/sd)	AOSTRA	SOLV-EX		NORTHLAND FOREST PRODUCTS	FORT McMURRAY HOSPITAL	TOTAL
		BITUMOUNT	RUTH LAKE			
SO_2	0.061	3.57	3.78	0.03	0.005	7.4
NO_x	0.226	0.645	1.71	0.27	0.007	2.8
CO_2	183.2	1050	1500	918	n/d	3651
CO	0.052	0.29	0.34	35.1	0.006	35.8
PM_c	n/d	1.25	0.77	0.27	0.003	2.3
THC	0.009	2.45	0.05	2.97	0	5.5
TRS	n/d	0.007	negligible	0	n/d	0.007

B1.4 TRANSPORTATION AND RESIDENTIAL SOURCE EMISSIONS

There are a number of non-industrial sources of NO_x, CO and CO_2 emissions in the Athabasca Oil Sands region that result from combustion sources. Specifically, these sources include the following:

- Highway 63 traffic (gasoline and diesel fuelled vehicles).
- Local community traffic (gasoline and diesel fuelled vehicles).
- Natural gas combustion for residential and commercial space heating, cooking and water heating.
- Residential wood combustion (fireplace or wood stove).
- Natural sources.

The two primary communities are Fort McMurray and Fort MacKay with respective populations of 34,706 and 332. The number of occupied residences are 11,295 and 103, respectively. For the most part, natural gas is used as the primary heating source in both communities. Table B1.0-12 summarizes the emissions from these other sources.

TABLE B1.0-12
SUMMARY OF EMISSIONS FROM
TRANSPORTATION AND RESIDENTIAL SOURCES

EMISSION (t/cd)	HIGHWAY	FORT McMURRAY			FORT MacKAY		
		TRAFFIC	RESIDENTIAL		TRAFFIC	RESIDENTIAL	
			NATURAL GAS	WOOD		NATURAL GAS	WOOD
SO_2	0.01	0.18	0.002	0.0026	0.00	0	0
NO_x	0.46	0.58	0.276	0.0171	0.003	0.006	0.0002
CO_2	81	114	368	15.1	0.53	8.5	0.140
CO	1.56	2.18	0.118	1.58	0.01	0.003	0.0147
PM_c	1.09	1.53	0.015	0.214	0.007	0.0003	0.002
THC	0.27	0.90	0.033	0.097	0.004	0.0008	0.0094
VOC	-	-	-	1.016	-	-	0.0009

B1.5 SUMMARY OF CURRENT EMISSIONS

Table B1.0-13 summarizes the emissions from Suncor, Syncrude, other industrial, transportation and residential sources in the oil sands region. While the results in the table indicate the two oil sands operations are the major sources of emissions to the atmosphere, there are other smaller sources that can also influence air quality. This is especially true for those smaller sources which originate from the communities.

B2.0 TOPOGRAPHY

The path followed by a plume and the turbulence levels that result in the dilution of the plume can be affected by terrain features such as valleys and hills. The magnitude of the terrain effect is dependent on factors such as terrain elevation, the slope of the terrain feature, the relative height of the plume with respect to the terrain and the meteorological conditions.

TABLE B1.0-13
SUMMARY OF CURRENT EMISSIONS IN THE ATHABASCA OIL SANDS REGION

	EMISSION RATES (t/cd)						
	SO_2	NO_x	CO_2	CO	PM_c	THC	TRS
Suncor	234	37.1	9643	21.4	6.8	42.3 (23.4)[b]	0.7
Syncrude	207	31.7	27,733	54.0	13.9	17.2	0.8
Other Industries[a]	7.4	2.8	3651	35.8	2.3	5.5	0.007
Transportation	0.2	1.0	196	3.8	2.6	1.2	n/d
Residential Combustion	0.005	0.3	392	1.7	0.2	1.1	n/d
Total	449	72.9	37,615	116.7	25.8	67.3 (48.4)[b]	1.5

(a) t/sd. Includes the currently approved Solv-Ex Bitumount and Ruth Lake facilities.
(b) The THC values shown in brackets refer to the Suncor emissions after the VRU is fully operational.

Step-like terrain features can cause complex recirculating flow patterns in their immediate vicinity, while a valley can generate its own air flow path independent of the regional winds above the valley. In some cases, the plume will flow around dominant terrain features while in other cases the plume will flow over the terrain. In extreme cases, the plume may impinge directly on the terrain feature in its path.

Figure B.2.0-1 shows the terrain on a regional scale. The dominant terrain features on a regional scale include:

- The Athabasca River Valley which has a general north-south orientation in the vicinity of the plants.
- The Clearwater River Valley which has a general east-west orientation.
- The highest elevations are associated with the Birch Mountains 50 km to the northwest of the plant area. At a distance of 75 km to the northwest, these mountains reach an elevation of 820 m ASL.
- Muskeg Mountain is about 40 km to the east of the plant area. At a distance of 55 km, this mountain reaches an elevation of 665 m ASL.
- The Thickwood Hills are about 20 km to the southwest of the plant area. At a distance of 25 km, these hills rise to an elevation of 515 m ASL.
- Stoney Mountain is about 60 km to the south of the plant area. At a distance of 65 km, this mountain rises to an elevation of 760 m AMSL.

For the purposes of comparison, the base elevation of the Suncor plant stacks is about 259 m ASL and the base elevation of the Syncrude plant stack is about 304 m ASL.

The roughness and smoothness of a vegetation canopy affect the wind speed and turbulence profiles. The oil sands area is located in the Boreal Forest Region which supports a variety of upland and lowland vegetation. The area is characterized by forest associations of white spruce, black spruce, jack pine, balsam fir, tamarack, aspen, balsam poplar and white birch.

Mature tree heights range from 10 m for black spruce in low-lying areas to 30 m for jack pine located on sandy soils. Mature white spruce and aspen forest stands tend to be 25 and 15 m in height, respectively. Due to differing soil types and drainage patterns, the vegetation cover is non-uniform within the region.

B3.0 METEOROLOGY

Suncor currently maintains a network of five ambient air quality monitoring stations in the vicinity of their operations. In the summer of 1993, the meteorological instrumentation at their Lower Camp and Mannix stations was upgraded to meet the needs associated with their Supplemental Emission Control (SEC) program as well as the needs of a regional-based meteorological monitoring program. The objective of the enhanced meteorological monitoring program is to gain a better understanding of plume-level air flow and dispersion characteristics in the vicinity of the Fort McMurray oil sands operations.

Figure B3.0-1 shows the relative heights of the two towers and the levels at which selected meteorological parameters are collected. The Lower Camp station is comprised of a communications tower that is instrumented at the 20, 45, 100 and 167 m levels. The Mannix station is comprised of a communications tower that is instrumented at the 20, 45 and 75 m levels. The data were reviewed and a summary of the data recovery efficiencies is provided in Table B3.0-1. For the 20 month period, from November 1, 1993 to June 30, 1995, the data recoveries were generally in the 95% plus range.

Meteorological data are specifically required as input for dispersion models that simulate the transport and dispersion of plumes released into the atmosphere. The models specifically require hour-by-hour values for:

- Wind directions representative of the layer the plumes are transported within;
- Wind speed for those layers;
- Atmospheric stability class;
- Ambient temperature; and

- Mixing height.

In addition, a number of parameters that vary with stability class are also required. These include temperature gradients and power law wind profile exponents.

B3.1 WIND RELATED OBSERVATIONS

- **Wind Direction.** Wind directions at both sites tend to be either from the south-southwest to south-southeast sector or from the north to northeast sector (Figure B3.0-2). These two sectors represent the orientation of the Athabasca River Valley. The only exception is the Lower Camp 20 m level which tends to indicate crossvalley flows. These data and/or instrumentation at this level warrant further investigation.
- **Wind Speed.** Median wind speeds at Lower Camp range from 8 km/h at the 20 m level to 14 km/h at the 167 m level. At Mannix, median wind speeds range from 8 km/h at the 20 m level to 14 km/h at the 75 m level (Figure B3.0-3). Wind speeds less than 11 km/h (3 m/s) occur one-third of the time at the Mannix 75 m and Lower Camp 167 m levels. The highest frequency of wind speeds greater than 19 km/h (5 m/s) occurs during the fall.
- **Surface Roughness Length.** The median surface roughness lengths derived from Lower Camp and Mannix wind data are 0.8 and 1.2 m, respectively. For the purposes of modelling, a value of 1.0 is assumed to be representative for the area.

TABLE B3.0-1
DATA RECOVERY EFFICIENCIES FOR METEOROLOGICAL PARAMETERS MEASURED AT THE LOWER CAMP AND MANNIX MONITORING TOWERS FROM NOVEMBER 1, 1993 TO JUNE 30, 1995

PARAMETER	LOWER CAMP	MANNIX
	EFFICIENCY (%)	EFFICIENCY (%)
Wind Direction and Standard Deviation[a]		
167 m level	97.5 (97.3)	-[c]
100 m level[b]	97.6 **(64.7)**	-
75 m level	-	97.7 (97.5)
45 m level	**56.7 (56.4)**	97.7 (97.5)
20 m level	97.4 (96.6)	97.1 (96.6)
Wind Direction and Standard Deviation		
167 m level	96.9 (96.9)	-
100 m level	97.5 (97.5)	-
75 m level	-	97.7 (97.7)
45 m level	97.6 (97.6)	**55.3 (55.3)**
20 m level	92.4 (92.4)	95.8 (95.8)
Temperature		
20 m level	98.2	97.8
Delta Temperature		
167 to 20 m	93.4	-
100 to 20 m	98.2	-
75 to 20 m	-	97.8
45 to 20 m	98.2	97.8
Net Radiation	-	97.1

PARAMETER	LOWER CAMP	MANNIX
	EFFICIENCY (%)	EFFICIENCY (%)
Relative Humidity	-	**37.5**
Standard Deviation of Vertical Wind		
167 m level	97.8	-
100 m level	97.8	-
75 m level	-	97.6
45 m level	97.8	97.6
20 m level	90.3	97.6

[a] Standard deviations greater than or equal to 90 degrees were not included.
[b] Boldface type indicates data recovery efficiencies less than 90%.
[c] Parameter was not measured at this level and/or tower.

B3.2 ATMOSPHERIC STABILITY CLASS RELATED OBSERVATIONS

- **Horizontal Turbulence (σ_θ).** The largest values of σ_θ tend to be associated with light wind speeds and with either convective turbulence during the day or increased meander during the night. The neutral values of σ_θ at the 20 m level for the Lower Camp and Mannix sites were 14 and 21 degrees, respectively.
- **Vertical Turbulence (σ_ϕ).** The largest values of σ_ϕ tend to be associated with light winds. Neutral values of σ_ϕ at the 20 m level for the Lower Camp and Mannix sites were 6 to 10 degrees, respectively.
- **Stability Class.** The stability class determination was based on the Mannix data and the U.S. EPA σ_ϕ method. The calculated stability class frequencies compared reasonably well with stability classes from Fort McMurray Airport observations (Figure B3.0-4). Based on Suncor data, unstable, neutral and stable atmospheres occur 16, 61 and 23% of the time, respectively. Figure B3.0-5 indicates unstable conditions (Classes A, B and C) occur during the day and stable cases (Classes E and F) occur during the night. Neutral conditions (Class D) can occur anytime of the day.

B3.3 TEMPERATURE RELATED OBSERVATIONS

- **Temperature.** Mean temperatures at the Mannix and Lower Camp sites ranged from approximately -18°C in February to 20°C in July. Extreme temperatures (i.e., above 30°C and below -30°C) were observed in the months from May to September and November to March, respectively. The annual average temperature was approximately 0°C.
- **Temperature Gradient.** Temperature gradients at lower levels exhibit stronger gradients than those at elevated levels due to the heating and cooling processes at the ground. Winter temperature gradients are associated with stable values while summer gradients are associated with neutral and unstable values.

B3.4 MIXING HEIGHT ESTIMATION

- **Net Radiation.** The mean net radiation values observed for each season are 11, 72, 115, and 27 W/m^2 for winter, spring, summer and fall, respectively.
- **Mixing Heights.** An empirical relationship based on net radiation (R_{net}) was used to calculate convective mixing height. Mechanical mixing height values were calculated from the Mannix station data using the 20 m level wind speeds and a surface roughness of 1 m. The larger of these two values was used for each hour of data. In late afternoon in spring and summer, the largest predicted mixing heights are in the 1600 to 2000 m range. During night-time hours and in winter, predicted mixing heights are in the 400 to 500 m range (Figure B3.0-6).

B3.5 RELATIVE HUMIDITY AND PRECIPITATION

- **Relative Humidity.** Winter median relative humidity values range from 78 to 82%. Spring and summer median values range from 31 to 76%. Fall median values range from 77 to 88%. The largest relative humidity values are associated with night-time conditions and the lowest with the mid-afternoon period.
- **Precipitation.** The most precipitation in the area occurs in summer months and the least in winter. Summer has the highest frequency of precipitation and spring the least.

Background Report 3 (Meteorological Observations in the Athabasca Oil Sands Region) provides more detail for the meteorological data collected by the Suncor enhanced monitoring program.

B4.0 AIR QUALITY OBSERVATIONS

The ambient air quality monitoring program in the Athabasca oil sands region is comprised of continuous monitoring, passive monitoring, precipitation monitoring and specialized studies.

Suncor, Syncrude and Alberta Environmental Protection (AEP) collectively maintain 12 continuous ambient air quality stations and 76 passive monitoring stations. AEP and Environment Canada collectively maintain eight precipitation monitoring stations in northern Alberta and Saskatchewan. These monitoring programs are further supplemented by short-term specialized studies that have focused on characterizing ambient hydrocarbon and reduced sulphur species concentrations, odours and deposition.

B4.1 CONTINUOUS MONITORING SUMMARY

Five and one-half years of continuous ambient air quality data (January 1990 to June 1995) from the 12 Suncor, Syncrude and Alberta Environmental Protection monitoring stations were reviewed, summarized and compared to air quality guidelines (Figure B4.0-1 and Table B4.0-1).

B4.1.1 SO_2 Concentrations

Relatively high SO_2 concentrations (in excess of the 0.34 ppm or 900 $\mu g/m^3$ guideline) have been observed on the edge of the Athabasca River valley escarpment adjacent to Suncor (that is, at the Fina and Mannix sites) (Table B4.0-2). While exceedences of the 0.17 ppm or 450 $\mu g/m^3$ guidelines have been observed at least once at all of the monitoring sites, these exceedences are most frequently observed at the Fina and Mannix stations and least frequently at the AQS5 (Syncrude Tailings East) and FMMU (Fort McMurray) stations (Table B4.0-3). The maximum one-hour average concentrations observed in Fort McMurray and Fort MacKay are 0.18 ppm (475 $\mu g/m^3$) and 0.26 ppm (690 $\mu g/m^3$), respectively.

The relatively high SO_2 concentrations are well correlated with either one of the two oil sands plants being located upwind. The high values tend to be associated with day-time hours and with wind speeds less than 10 km/h. Convective and/or limited trapping meteorological conditions are associated with these SO_2 events.

TABLE B4.0-1

SUMMARY OF PARAMETERS CURRENTLY MONITORED ON A CONTINUOUS BASIS

OPERATION	STATION	U	θ	SO_2	H_2S	NO_x	THC	O_3	CO
Suncor	Mannix (#2)	✓	✓	✓	✓	×	✓	×	×
	Lower Camp (#4)	✓	✓	✓	✓	×	✓	×	×
	Fina Airstrip (#5)	✓	✓	✓	✓	×	×	×	×
	Poplar Creek (#9)	✓	✓	✓	✓	×	✓	×	×
	Athabasca Bridge (#10)	✓	✓	✓	✓	×	✓	×	×
Syncrude	AQS1 (Mine South)	✓	✓	✓	✓	×	×	×	×
	AQS2 (Fort McMurray)	✓	✓	✓	✓	×	✓	×	×
	AQS3 (Mildred Lake)	✓	✓	✓	✓	×	×	×	×
	AQS4 (Tailings North)	✓	✓	✓	✓	✓	✓	×	×
	AQS5 (Tailings East)	✓	✓	✓	✓	×	×	×	×
Alberta Environmental Protection	FMMU (Fort McMurray)	✓	✓	✓	✓	✓	✓	✓	✓
	FRMU (Fort MacKay)	✓	✓	✓	✓	×	✓	×	×

✓ = currently being monitored
× = not being monitored
U = wind speed
θ = wind direction
SO_2 = sulphur dioxide
H_2S = hydrogen sulphide
NO_x = oxides of nitrogen
THC = total hydrocarbons
O_3 = ozone
CO = carbon monoxide

TABLE B4.0-2
NUMBER OF HOURLY SO_2 CONCENTRATIONS GREATER THAN 0.34 ppm (900 $\mu g/m^3$)

STATION	1990	1991	1992	1993	1994	1995[a]	TOTAL	AVERAGE
Mannix (#2)	3	1	0	0	3	0	7	1.3
Lower Camp (#4)	4	1	0	0	0	0	5	0.9
Fina (#5)	4	4	1	3	0	1	13	2.4
Poplar Creek (#9)	0	0	0	0	1	0	1	0.2
Athabasca Bridge (#10)	0	0	0	0	0	0	0	0
AQS1 (Mine South)	0	0	0	0	2	0	2	0.4
AQS2 (Fort McMurray)	0	0	0	0	0	0	0	0
AQS3 (Mildred Lake)	0	0	0	0	1	0	1	0.2
AQS4 (Tailing North)	0	0	0	0	0	0	0	0
AQS5 (Tailing East)	0	0	0	0	0	0	0	0
Fort McMurray (FMMU)	0	0	0	0	0	0	0	0
Fort MacKay (FRMU)	0	0	0	0	0	0	0	0
Total	11	6	1	3	7	1	29	5.3

(a) January to June.

The ambient SO_2 concentrations observed at Suncor's monitoring stations have exceeded the daily objective of 150 $\mu g/m^3$ (0.06 ppm) from a combined high of 9 days per year in 1990 to a combined low of 2 days per year in 1993. The average number of combined daily exceedences over the 1990 to 1995 period is 3 days per year.

Background annual values of SO_2 are expected to be in the 1 to 4 $\mu g/m^3$ range (summer and winter, respectively). This value is based on extrapolating measurements from Cree Lake, Saskatchewan and Vegreville, Alberta to the region. The compliance monitoring program conducted by Suncor, Syncrude and AEP does not allow meaningful annual or background values to be calculated.

B4.1.2 H_2S Concentrations

Relatively high H_2S concentrations (in excess of 10 ppb or 14 $\mu g/m^3$) have been observed at all locations. The most frequent exceedences have been observed at the Mannix, Lower Camp and AQS3 (Mildred Lake) Stations (Table B4.0-4). Most of these exceedences were observed in 1990 with the following years showing a decrease.

The relatively high H_2S concentrations were observed during the summer and during the night-time periods. The H_2S events are, for the most part, well correlated with either one of two oil sands plants being located upwind. It is likely that the H_2S events result from low-level H_2S sources that are transported downwind under stable atmospheric conditions.

TABLE 4.0-3
NUMBER OF HOURLY SO_2 CONCENTRATIONS GREATER THAN 0.17 ppm (450 $\mu g/m^3$)

STATION	1990	1991	1992	1993	1994	1995	TOTAL	AVERAGE
Mannix (#2)	21	7	5	9	21	20	83	14
Lower Camp (#4)	18	11	1	3	6	5	44	7
Fina (#5)	41	20	9	14	16	21	121	20
Poplar Creek (#9)	0	0	2	0	4	4	10	2
Athabasca Bridge (#10)	0	0	2	2	6	2	12	2
AQS1 (Mine South)	6	2	0	3	7	4[a]	22	4
AQS2 (Fort McMurray)	1	2	0	0	5	0[a]	8	2
AQS3 (Mildred Lake)	4	3	5	4	8	4[a]	28	5
AQS4 (Tailing North)	4	2	1	0	3	3[a]	13	2
AQS5 (Tailing East)	0	0	0	0	1	0[a]	1	0.2
Fort McMurray (FMMU)	0	0	0	0	0	1[a]	1	0.2
Fort MacKay (FRMU)	0	2	1	1	2	2[a]	8	2
Total	95	49	26	36	79	66	341	60

[a] To June 30, 1995.

TABLE B4.0-4
NUMBER OF HOURLY H_2S CONCENTRATIONS GREATER THAN 0.01 ppm (10 ppb or 14 $\mu g/m^3$)

STATION	1990	1991	1992	1993	1994	1995	TOTAL	AVERAGE
Mannix (#2)	44	37	5	24	42	10	162	27
Lower Camp (#4)	100	7	0	2	2	4	115	19
Fina (#5)	-	-	-	-	2	-	2	2
Poplar Creek (#9)	0	15	1	0	0	4	20	3
Athabasca Bridge (#10)	1	0	0	1	2	2	6	1
AQS1 (Mine South)	10	2	0	4	10	0[(a)]	26	4.7
AQS2 (Fort McMurray)	3	0	0	3	13	0[(a)]	19	3.5
AQS3 (Mildred Lake)	80	4	1	3	1	0[(a)]	89	16
AQS4 (Tailing North)	2	1	0	5	6	2[(a)]	16	2.9
AQS5 (Tailing East)	0	1	0	0	0	2[(a)]	3	0.5
Fort McMurray (FMMU)	1	5	0	0	5	0[(a)]	11	2.0
Fort MacKay (FRMU)	1	0	0	0	0	2[(a)]	3	0.5
Total	242	72	7	42	83	26	472	82

(a) Up to June 30, 1995.

B4.1.3 NO_x Concentrations

NO_x was only observed at the AQS4 (Tailings North) and FMMU (Fort McMurray) stations. Two hourly NO_x values at AQS4 were observed to exceed 400 $\mu g/m^3$ (0.21 ppm). Both these values were attributed to exhaust emissions from vehicles left running adjacent to the station. Only one exceedence of the 400 $\mu g/m^3$ (0.21 ppm) NO_2 guideline was observed in Fort McMurray. High NO_x concentrations in Fort McMurray tend to occur during the winter months and during the evening hours. The likely sources of high ambient NO_x concentrations in Fort McMurray are residential wood combustion and local traffic.

A review of the NO_2/NO_x ratio indicated a dependence on the NO_x concentrations. For small NO_x concentrations (that is, less than 0.05 ppm), the NO_2 concentration is typically 55 to 75% of the NO_x value. For larger NO_x concentrations (that is, greater than 400 $\mu g/m^3$), the NO_2 concentration is typically 20% of the NO_x value.

B4.1.4 O_3 Concentrations

Relatively high ozone (O_3) levels are observed in Fort McMurray during the late spring and summer months. Ozone events tend to occur during the afternoon hours. While exceedences of the hourly guideline (160 $\mu g/m^3$, 80 ppb or 0.08 ppm), are relatively infrequent, exceedences of the daily guideline (50 $\mu g/m^3$, 25 ppb or 0.025 ppm) occur on average about 135 days per year (Table B4.0-5).

High ozone concentrations have been observed in rural areas of Alberta (Angle and Sandhu 1986, Peake and Fong 1990). Exceedences of the guideline occur more frequently in rural than in urban areas such as Calgary and Edmonton. Exceedences of the daily guidelines have been observed 50 to 90% of the time in rural Alberta areas compared with only 10 to 40% of the time in urban areas (Angle and Sandhu 1989).

B4.1.5 CO Concentrations

CO values observed in Fort McMurray have all been within the 13 ppm (15,000 $\mu g/m^3$) guideline (as a one hour average). The higher CO values are associated with the winter period and tend to occur during the evening hours. Local sources (i.e., residential wood combustion) are likely the most significant contributor to the CO values observed in Fort McMurray.

B4.1.6 THC Concentrations

While median THC concentrations are typically in the 1.4 to 2.1 ppm range, maximum values in excess of 30 ppm have been reported in Athabasca River valley locations (that is, Poplar Creek and Athabasca Bridge) (Table B4.0-6). These values suggest channelling of emissions from low level fugitive hydrocarbon sources by the valley. Further along the valley, the maximum observed values are less at Fort McMurray (8.6 ppm) and Fort MacKay (4.1 ppm).

B4.1.7 Particulates

Total suspended particulate matter (TSP or PM) is measured at AQS2 (Fort McMurray) and AQS4 (Tailings North). While the annual mean concentrations at both sites have been less than the 60 $\mu g/m^3$ guideline, three exceedences of the daily guideline of 100 $\mu g/m^3$ have been observed at AQS4. One was attributed to a forest fire contribution and another one was attributed to a diesel engine left running near the station. There appears to be a tendency for decreasing PM values over the period 1990 to 1994.

TABLE B4.0-5
SUMMARY OF HOURLY AND DAILY O_3 CONCENTRATIONS OBSERVED AT FORT McMURRAY

STATION	1990	1991	1992	1993	1994	1995[(a)]	COMBINED
Hourly Statistics							
Mean (ppb)	25	22	21	22	24	25	23
Median (ppb)	22	21	20	21	22	23	22
Maximum (ppb)	89	65	59	91	77	71	91
N ≥ 80 ppb (h/a)	16	0	0	4	0	0	3.6
Daily Statistics							
Mean (ppb)	25	22	21	22	24	25	23
Median (ppb)	23	22	21	21	23	25	22
Maximum (ppb)	68	43	43	54	58	50	68
N ≥ 25 (ppb) (d/a)	156	131	91	127	153	86	135

(a) Up to June 30, 1995.

TABLE B4.0-6
MEDIAN AND MAXIMUM THC CONCENTRATIONS (ppm)

		POPLAR CREEK (#9)	ATHABASCA BRIDGE (#10)	AQS2 (FORT McMURRAY)	AQS4 (TAILINGS NORTH)	FORT McMURRAY (FMMU)	FORT MacKay (FRMU)
Median	1990	2.0	2.1	n/a[(a)]	1.8	1.6	1.8
	1991	1.9	1.7	1.7	1.8	1.6	1.6
	1992	1.8	2.0	1.8	2.0	1.8	1.7
	1993	1.7	1.9	1.6	1.8	2.0	1.8
	1994	1.5	1.6	1.4	1.5	2.2	1.7
	1995	1.6	n/a	1.6	1.7	2.0	1.7
Maximum	1990	9.0	30.9	n/a	5.9	3.5	4.1
	1991	7.4	13.5	4.0	6.1	8.6	3.5
	1992	9.1	12.7	3.1	7.0	3.8	3.9
	1993	51.4	35.0	3.3	5.7	3.2	3.6
	1994	11.1	13.7	4.6	4.3	3.7	3.3
	1995	18.6	n/a[(a)]	2.7	14.6	2.7	3.5

(a) No data collected.

B4.2 PASSIVE MONITORING SUMMARY

The locations of the passive samplers are biased on a north/south axis parallel to the Athabasca River valley. Maximum total sulphation and hydrogen sulphide values occur in the vicinity of each plant and in the river valley near Lower Camp (Figure B4.0-2).

A review of selected Suncor, Syncrude and AEP passive samplers for total sulphation and hydrogen sulphide that are closely located indicated biases that may be due to either the sampling approach and/or the analytical approach. Adjustment factors were applied to normalize the data prior to analysis.

B4.3 PRECIPITATION CHEMISTRY SUMMARY

B4.3.1 Precipitation Chemistry

The average acidity (pH) of the precipitation observed in Fort McMurray (pH 4.8) is more acidic than other locations measured in northern Alberta or Saskatchewan (pH = 5.0 to 5.3). Table B4.0-7 compares the wet deposition of specific anions and cations observed in Fort McMurray with other northern locations. Generally, the lowest deposition values are observed at Cree Lake, Saskatchewan (SO_4^{-2}, Ca^{+2}, Mg^{+2}, NH_4^+). For some ions (SO_4^{-2}, NO_3^- and NH_4^+), the highest values were observed at Vegreville, Alberta.

The annual average acidifying potential (AP) observed in Fort McMurray is 0.03 kmol H^+ equivalent/ha/a. This compares to the range of -0.02 to +0.02 kmol H^+ equivalent/ha/a observed at the other locations.

TABLE B4.0-7
COMPARISON OF PRECIPITATION CHEMISTRY OBSERVED AT FORT McMURRAY WITH OTHER NORTHERN ALBERTA LOCATIONS

ANION / CATION	WET DEPOSITION (kg/ha/a)	
	FORT McMURRAY	OTHER
SO_4^{-2}	4.9	1.7 to 5.6
NO_3^-	2.3	0.9 to 4.2
Ca^{+2}	1.1	0.2 to 1.2
Mg^{+2}	0.25	0.05 to 0.19
NH_4^+	0.4	0.3 to 2.2

The annual average effective acidity (EA) observed in Fort McMurray is 0.06 kmol H^+ equivalent/ha/a. This compares to the range of 0.03 to 0.13 kmol H^+ equivalent/ha/a observed at the other northern Alberta and Saskatchewan locations.

B4.3.2 Dry Deposition

The estimation of dry deposition requires accurate low concentration measurements that are not achievable with the current monitoring program. The closest locations to northeastern Alberta where these measurements are available are Cree Lake in north-central Saskatchewan and Vegreville, in central Alberta. Cree Lake is about 350 km to the east of the oil sands region and Vegreville is about 400 km to the south of the oil sands region.

Background concentration measurements at Cree Lake and Vegreville were used to estimate dry deposition of selected compounds. The results can be summarized as:

- The dry deposition of sulphur compounds expressed as sulphate equivalent ranges from 4.7 kg SO_4^{-2} equivalent/ha/a at Cree Lake to 17.5 kg SO_4^{-2} equivalent/ha/a at Vegreville. About 70% of the deposition is in the dry form.

- The dry deposition of NH_4^+ ranges from 0.07 kg NH_4^+/ha/a at Cree Lake to 0.26 kg NH_4^+/ha/a at Vegreville. About 15% of the deposition is in the dry form.
- The dry deposition of the other nitrogen containing compounds expressed as nitrate equivalent ranges from 1.8 kg NO_3^- equivalent/ha/a at Cree Lake to 8.0 kg NO_3^- equivalent/ha/a at Vegreville. About 60% of the deposition is in the dry form.

The calculated dry contribution to the Effective Acidity (EA) at Cree Lake and Vegreville are 0.08 and 0.29 kmol H^+/ha/a, respectively. This compares to the corresponding wet contributions of 0.05 and 0.13 kmol H^+/ha/a at the two respective sites. The dry component of the EA is about 65% of the total EA.

B4.4 SPECIAL STUDIES SUMMARY

A number of short-term and/or specialized monitoring programs have been conducted by the oil sands operations and others in the region. These studies are summarized in the following subsections.

B4.4.1 Fort McMurray

A second monitoring station was installed in downtown Fort McMurray for the period October 1991 to June 1992. Air quality data collected at this station were compared to the corresponding data collected at the permanent Fort McMurray station. The study concluded that the permanent station location was suitable to monitor pollutants transported into Fort McMurray from the oil sands region.

B4.4.2 THC and TRS Monitoring

Alberta Environmental Protection conducted a mobile ambient air monitoring survey in 1990. The results of the study indicated:

- Relatively high SO_2 and THC levels were associated with plant flaring events.

- Relatively high THC concentrations were observed within the Suncor and Syncrude facilities.

Suncor conducts a nominal two mobile ambient monitoring surveys per year for reduced sulphur species and total hydrocarbons. Relatively high values have been observed in the vicinity of the Plant 4 discharge to Tailings Pond 1, the tank farms and the plant area.

B4.5 ODOUR ASSESSMENT STUDIES

A number of assessment studies have been conducted to identify and quantify odours resulting from the Suncor plant. The studies identified Tailings Pond 1 as having a high potential for causing off-site odours whereas the Powerhouse stack emissions was defined as a low-medium potential for causing off-site odours. Further details are provided in the Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region.

A review of the odour complaint information collected in response to the initiation of a regional odour response protocol indicated that the odour identification and tracking process appears to have resulted in a reduction of both the frequency and magnitude of odour incidents over the 1991 to 1994 period (Table B4.0-8). This reduction may be a result of improved operational efficiencies that have reduced the frequency or magnitude of odour causing emissions, a reduction in community response or a combination of both.

B4.6 THROUGHFALL AND STEMFLOW STUDIES

- A monitoring program was conducted in 1976 to measure sulphate deposition in precipitation and in the throughfall and stemflow below a tree canopy. Two components of the program were reviewed: the nutrient cycling program conducted at two sites and a field studies program conducted at 14 sites. The results can be summarized as follows:

TABLE B4.0-8
SUMMARY OF ODOUR COMPLAINTS AND INCIDENTS OVER THE PERIOD 1991 TO 1994

		COMPLAINT LOCATIONS												ODOUR SOURCES											
		TOTAL			Fort McMurray			Fort MacKay			OTHER			SUNCOR			SYNCRUDE			BOTH			OTHER / UNKNOWN		
Year	Quarter	C	I	C/I	C	I	C/I	C	I	C/I	C	I	C/I	C	I	C/I	C	I	C/I	C	I	C/I	C	I	C/I
1991	1	45	31	1.5	41	27	1.5	4	4	1	0	0	0	12	8	1.5	4	3	1.3	5	2	2.5	24	18	1.3
	2	50	26	1.9	48	24	2	2	2	1	0	0	0	25	11	2.3	3	2	1.5	1	1	1	21	13	1.6
	3	128	37	3.5	123	32	3.8	3	3	1	2	2	1	76	15	5.1	2	2	1	20	4	5	30	16	1.9
	4	118	28	4.2	113	23	4.9	5	5	1	0	0	0	94	9	10	3	1	3	1	1	1	20	16	1.3
	Annual	341	122	2.8	325	106	3.1	14	14	1	2	2	1	207	43	4.8	1.2	8	1.5	2.7	8	3.4	95	63	1.5
1992	1	43	28	1.5	39	24	1.6	4	4	1	0	0	0	13	6	2.2	1	1	1	15	9	1.9	14	13	1.1
	2	117	47	2.5	104	38	2.7	11	7	1.6	2	2	1	57	14	4.1	4	4	1	36	9	4	20	20	1
	3	100	39	2.6	96	35	2.7	4	4	1	0	0	0	14	7	2	2	2	1	69	17	4.1	15	13	1.2
	4	54	20	2.7	54	20	2.7	0	0	0	0	0	0	35	3	12	0	0	0	1	1	1	18	16	1.1
	Annual	314	134	2.3	293	117	2.5	19	15	1.3	2	2	1	119	30	4	7	7	1	121	35	3.5	67	62	1.1
1993	1	14	0	0	0	0	0	0	0	0	0	0	0	14	0	0	4	0	0	6	0	0	1	0	0
	2	28	0	0	0	0	0	0	0	0	0	0	0	11	0	0	2	0	0	7	0	0	8	0	0
	3	69	20	3.5	65	18	3.6	0	0	0	4	2	2	46	8	5.8	10	2	5	2	2	1	11	8	1.4
	4	30	22	1.4	26	18	1.4	4	4	1	0	0	0	1	1	1	0	0	0	11	4	2.8	18	17	1.1
	Annual	141	42	3.4	91	36	2.5	4	4	1	4	2	2	72	9	8	15	2	7.5	26	6	4.3	38	25	1.5
1994	1	14	13	1.1	12	11	1.1	2	2	1	0	0	0	5	4	1.3	0	0	0	1	1	1	8	8	1
	2	46	26	1.8	40	20	2	4	4	1	2	2	1	12	4	3	2	2	1	17	8	2.1	15	12	1.3
	3	29	16	1.8	3	3	1	3	1	3	10	4	2.5	10	4	2.5	0	0	0	10	4	2.5	15	12	1.3
	4	24	15	1.6	21	12	1.8	2	2	1	1	1	1	5	3	1.7	2	2	1	10	4	2.5	7	6	12
	Annual	113	70	1.6	76	46	1.7	11	9	1.2	13	7	1.9	32	15	2.1	4	4	1	38	17	2.2	45	38	1.2
	Total	909	368		785	305		48	42		21	13		430	97		38	21		212	66		245	188	

C = # of Complaints
I = # of Incidents
C/I = Complaint/Incidents

- Both studies indicated greater sulphate in throughfall and stemflow than that in the rainfall which indicates a dry deposition contribution. Most of the dry deposition is associated with the throughfall component.
- The nutrient cycling study indicated **wet deposition** values of about 1.9 kg SO_4^{-2}/ha/a at the more distant site (101 km) and values greater than 4.4 kg SO_4^{-2}/ha/a at the closer site (32 km).The field studies component at the 14 sites indicated **wet deposition** ranging from 2.4 to 9.0 kg SO_4^{-2}/ha/a. At the more distant locations (> 60 km), the wet deposition values were in the 2.5 to 4.0 kg SO_4^{-2}/ha/a range.

This compares to the more recent wet deposition values of 1.9 kg SO_4^{-2}/ha/a and 4.9 SO_4^{-2}/ha/a observed at Cree Lake and Fort McMurray, respectively.

- The nutrient cycling study indicted similar **dry deposition** values at each site (3.2 kg SO_4^{-2}/ha/a for trembling aspen 8.8 kg SO_4^{-2}/ha/a for jack pine).
- While the **dry deposition** values at individual sites ranged from 3.8 to 67 kg SO_4^{-2}/ha/a, the average values at various downwind distance ranges were: 13.4 kg SO_4^{-2}/ha/a (0 to 20 km); 30.9 kg SO_4^{-2}/ha/a (20 to 40 km); and 17.3 kg SO_4^{-2}/ha/a (60 to 100 km). A value of 5.9 kg SO_4^{-2}/ha/a was observed at a background site 173 km from the plant.

For the purposes of comparison, the more recent estimates of **dry deposition** at Cree Lake is about 4.7 kg SO_4^{-2}/ha/a. The results of the throughfall and stemflow studies, in spite of some limitations, confirms that dry deposition is as or even more important than wet deposition.

B4.7 CONCLUSIONS

The operation of the Suncor and Syncrude oil sands facilities has resulted in changes to the quality of the air downwind of the facilities. The major changes appear to be associated with the emissions of SO_2 from the main stacks and from fugitive total hydrocarbon and total reduced sulphur emissions from lower level sources.

The SO_2 emissions have resulted in ambient SO_2 concentrations that are in excess of ambient guidelines. These exceedences occur most frequently in the vicinity of the Suncor site. The wet sulphate deposition is higher than in other regions in northern Alberta or Saskatchewan. Dry deposition may be as important or more important than wet deposition.

Fugitive hydrocarbon and reduced sulphur compound emissions from the oil sands plant area and associated ponds have resulted in off-site odours.

B5.0 DISPERSION MODEL PREDICTIONS

B5.1 MODEL APPROACH AND LIMITATIONS

Air quality simulation models provide a scientific means of relating industrial emissions to changes in ambient air quality. This modelling can complement ambient monitoring in terms of providing an understanding of air quality changes. As such, modelling forms an important component of an air quality assessment.

Four models were applied to the emission sources in the region:

- **SCREEN3.** This U.S. EPA model was used as a general model to evaluate the effect of emissions from stacks on ambient air quality.
- **ISC3BE.** This is a modified version of the U.S. EPA model ISCST3 which was used to evaluate ambient SO_2 concentrations resulting from the regional sources. The model was modified to produce predicted trends that were similar to observed trends.
- **ISC3BE.** This is a modified version of the U.S. EPA model ISCST3 which was used to evaluate ambient SO_2 concentrations resulting from the regional sources. The model was modified to produce predicted trends that were similar to observed trends.
- **ADEPT2.** This AEP model was used to evaluate annual SO_2 concentrations and the deposition of sulphur compounds from the major sources. A modified version of the

model using the dry deposition velocities specified by the Alberta Research Council was used.

- **Box Model.** A simple box model was used to evaluate hydrocarbon concentrations that could occur in Fort McMurray or Fort MacKay from fugitive oil sands emissions.

Dispersion models employ simplifying assumptions to describe the random processes associated with the atmospheric motions and turbulence. These simplifying processes limit the capability of a model to replicate individual events. A model's predictive capability and strength 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 model. Specifically, models require source data and meteorological information. Additionally, ambient air quality data are required to evaluate the performance of the model. For example, the following limitations are noted:

- The modelling does not account for hour-by-hour variations in the source strength and exit characteristics.
- There are limitations on the characterization of the secondary combustion sources and flaring events.
- The meteorological data do not fully reflect the more westerly flows that may be associated with the Syncrude main stack.
- The ambient air quality data are from a limited number of sites and do not accurately measure small concentration values.

Notwithstanding these limitations, the data used by the models and for the model evaluation did undergo a review in the background reports and they were found to be sufficient for the modelling application. Specifically, the model predictions show good agreement with observations, both in terms of magnitude and diurnal trends.

B5.2 SO_2 CONCENTRATIONS

The dispersion models were used to predict hourly average, daily average and annual average SO_2 concentration patterns. In addition, sulphur compound deposition and associated Effective Acidity patterns were also predicted. The basis for these predictions was focused primarily on the three major SO_2 sources: the Suncor Powerhouse and Incinerator stacks, and the Syncrude Main stack. Only hourly average SO_2 concentrations were estimated from flaring operations.

B5.2.1 Individual Operation (Hourly Average)

Maximum one-hour average concentrations associated with the current emission scenario were predicted using the SCREEN3 and ISC3BE models. The SCREEN3 predictions assumed flat terrain and the AEP 55% adjustment factor was not applied. The ISC3BE model assumed elevated terrain and the Mannix based meteorological data. The individual stack and emission parameters are provided in Table B5.0-1 and the associated model predictions are provided in Table B5.0-2. The information presented in these tables can be summarized as:

- The various SO_2 emissions in the tables reflect the temporal variability of the sources over differing averaging periods.
- The comparison between the maximum values predicted using both models shows good agreement for the Suncor sources.
- The SCREEN3 model tends to predict maximum SO_2 concentrations from the Syncrude Main stack that are larger than the ISC3BE predictions by a factor of two. The application of the AEP 55% factor would result in SCREEN3 predictions that are in better agreement with the ISC3BE predictions.
- The maximum values predicted with the SCREEN3 model are all associated with PG stability class A (day-time conditions) and the maximum values all occur between 0.8 and 1.4 km downwind of the respective sources.

- ISC3BE predicts maximum values associated with day-time conditions (PG stability classes A and B) and the maximum occurs at distances of 1.1 km from the Suncor Incinerator and 8.9 km from the Syncrude Main stack.
- ISC3BE also predicts maxima associated with night-time conditions (PG stability class E). These maxima are typically predicted at larger distances with elevated terrain (23.6 km downwind of the Powerhouse stack).

TABLE B5.0-1
SO_2 EMISSIONS ASSOCIATED WITH CONTINUOUS SOURCES IN THE REGION (CURRENT)

SOURCE		SUNCOR POWERHOUSE	SUNCOR INCINERATOR (BEFORE SUPERCLAUS)	SUNCOR INCINERATOR (AFTER SUPERCLAUS)	SYNCRUDE MAIN
Base elevation	(m ASL)	259	259	259	304
Stack height	(m)	106.7	106.7	106.7	183
Stack diameter	(m)	5.79	1.80	1.80	7.90
Exit velocity	(m/s)	22.3	18.5	20.3	27.2
Exit temperature	(°C)	256	489	478	239
SO_2 emission					
Average	(t/d)	211	35	17	213
Approved 90 day	(t/d)	-	-	-	260
Approved daily	(t/d)	259	51	-	292
Approved hourly	(t/h)	13.8	2.6	1.2	16.4
Approved abnormal	(t/h)	14.2	3.0	-	-

TABLE B5.0-2
MAXIMUM ONE-HOUR AVERAGE SO_2 CONCENTRATIONS ASSOCIATED WITH THE CURRENT (1994/1995) SO_2 EMISSION SOURCES IN THE REGION

SOURCE / SO_2 EMISSION	SCREEN3				ISC3BE					
	SO_2 CONCENTRATION				SO_2 CONCENTRATION				EXCEEDENCES	
	SO_2 (μg/m^3)	PG CLASS	WIND SPEED (m/s)	DISTANCE (km)	SO_2 (μg/m^3)	PG CLASS	WIND SPEED (m/s)	LOCATION[a] (km / degrees)	N >[b] 450 μg/m^3	LOCATION (km / degrees)
Continuous Suncor										
Powerhouse										
Average (211 t/d)	1237	A	2.5	1.2	1346	E	0.6	23.6 / 36	34	14.1 / 98
Daily (259 t/d)	1519	A	2.5	1.2	1652	E	0.6	23.6 / 36	45	15.1/ 98
Hourly (13.8 t/h)	1942	A	2.5	1.2	2173	E	0.6	23.6 / 36	57	19.4 / 102
Abnormal (14.2 t/h)	1998	A	2.5	1.2	2173	E	0.6	23.6 / 36	59	21.1 / 59
Incinerator (before SuperClaus)										
Average (35 t/d)	842	A	1.0	1.1	698	A	3.3	1.1 / 198	3	4.5 / 261
Daily (51 t/d)	1227	A	1.0	1.1	1017	A	3.3	1.1 / 198	25	2.2 / 202
Hourly (2.6 t/h)	1501	A	1.0	1.1	1244	A	3.3	1.1 / 198	97	2.2 / 207
Abnormal (3.0 t/h)	1732	A	1.0	1.1	1435	A	3.3	1.1 / 198	169	2.2 / 207
Incinerator (after SuperClaus)										
Average (17 t/d)	397	A	1.5	1.0	338	A	3.3	1.1 / 198	0	N/A
Hourly (1.2 t/h)	672	A	1.5	1.0	573	A	3.3	1.1 / 198	2[b]	10.2 / 101
Continuous Syncrude										
Main Stack										
Average (213 t/d)	662	A	3.0	1.4	322	B	5.7	8.9 / 6	0	N/A
90-day (260 t/d)	808	A	3.0	1.4	393	B	5.7	8.9 / 6	0	N/A
Daily (292 t/d)	908	A	3.0	1.4	441	B	5.7	8.9 / 6	0	N/A

SOURCE / SO_2 EMISSION	SCREEN3				ISC3BE					
	SO_2 CONCENTRATION				SO_2 CONCENTRATION				EXCEEDENCES	
	SO_2 ($\mu g/m^3$)	PG CLASS	WIND SPEED (m/s)	DISTANCE (km)	SO_2 ($\mu g/m^3$)	PG CLASS	WIND SPEED (m/s)	LOCATION[a] (km / degrees)	N >[b] 450 $\mu g/m^3$	LOCATION (km / degrees)
Hourly (16.4 t/h)	1223	A	3.0	1.4	595	B	5.7	8.9 / 6	1[c]	64.0 / 321
Average	1190	-	-	-	1024	-	-	-	-	-

(a) Direction is indicated as the wind direction.
(b) Normalized for a 12 month period.
(c) Indicates that there are more than one occurrence (receptor) of the same maximum number of exceedences.

Based on the ISC3BE predictions, the following are noted:

- The maximum SO_2 concentrations associated with the Powerhouse and Incinerator (before SuperClaus) are predicted to exceed the 450 $\mu g/m^3$ guideline (0.17 ppm) for all emission cases.

- The maximum predicted SO_2 concentrations associated with the incinerator (after SuperClaus) and the Syncrude Main stack are less than the 450 $\mu g/m^3$ guideline except during abnormal conditions that could occur on an hour-by-hour basis.

B5.2.2 Combined Operation

The combined operation of the three major continuous SO_2 sources was evaluated using the ISC3BE model for an "average" emission case and for a "maximum" case. The "maximum" case assumes all three stacks operate simultaneously at the approved daily values (Table B5.0-1). A maximum SO_2 emission of 26 t/d was assumed for the present SuperClaus operation. The maximum hourly, daily and annual average predictions are given in Table B5.0-3.

Figures B5.0-1 and B5.0-2 show the maximum predicted hourly SO_2 concentrations and the frequency of exceeding the 450 $\mu g/m^3$ guideline, respectively. Figures B5.0-3 and B5.0-4 show the maximum predicted daily and annual SO_2 concentrations, respectively.

The predictions indicate high values may occur over the elevated terrain associated with Thickwood Hills to the southwest and with Muskeg Mountain to the east. The ISC3BE model predicts SO_2 concentrations in excess of 450 $\mu g/m^3$ guideline are exceeded for more than 20 hours per year over the elevated terrain associated with the Muskeg Mountain to the east of Suncor and Thickwood Hills to the southwest of Suncor and Syncrude. The major contributor to the high predicted values in these areas are emissions from the Suncor Powerhouse stack.

TABLE B5.0-3

MAXIMUM PREDICTED SO_2 CONCENTRATIONS RESULTING FROM THE COMBINED OPERATION OF THE SO_2 EMISSION SOURCES IN THE REGION

EMISSION SCENARIO	1995	
SO_2 EMISSION	AVERAGE	MAXIMUM
Hourly Average		
Maximum SO_2 ($\mu g/m^3$)	1279	1652
Location (km/deg)	23.6 / 216	23.6 / 216
N > 450 $\mu g/m^3$	37	49
Location (km/deg)	14.1 / 98	14.1 / 98
Daily Average		
Maximum SO_2 ($\mu g/m^3$)	246	311
Location (km/deg)	25.6 / 231	25.6 / 231
N > 150 $\mu g/m^3$	1	3
Location (km/deg)	14.1 / 98	16.8 / 107
Annual Average		
Maximum SO_2 ($\mu g/m^3$)	12	16
Location (km/deg)	7.1 / 352	7.1 / 352

Hourly Guideline 450 $\mu g/m^3$
Daily Guideline 150 $\mu g/m^3$
Annual Guideline 30 $\mu g/m^3$

B5.2.3 Flaring Operations

Suncor has intermittent SO_2 emissions associated with plant start-up, shut-down or upset (abnormal) activities. Flaring events were reviewed and "typical" events were identified. The SCREEN3 model was used to estimate maximum one-hour average SO_2 concentrations that could result from these events. Given the short duration of these emissions, only maximum hourly values were predicted. The results can be summarized as:

- Maximum predicted hourly values can range up to 5623 μg/m^3 (2.1 ppm) given the simultaneous occurrence of worst case meteorological conditions and the flaring of acid gas from Unit 8C4.

- For other flaring cases, the maximum predicted hourly values range from 18 μg/m^3 (0.007 ppm) to 1650 μg/m^3 (0.62 ppm) given the simultaneous occurrence of flaring and the worst case meteorological conditions.

- Worst case meteorological conditions are day-time summer periods under strong solar heating conditions (PG stability class A).

- Maximum values associated with flaring under these conditions occur between 0.6 and 1.4 km from the respective flare stacks.

Although flaring is intermittent and of limited duration, flaring under certain meteorological conditions can result in relatively large short-term SO_2 concentrations.

B5.2.4 SO_2 Summary

The following summarizes the concentrations associated with SO_2 emission sources:

a) <u>Individual Operation</u>

- **Suncor Powerhouse:** Maximum predicted concentrations are in the 1346 to 2173 μg/m^3 (0.51 to 0.82 ppm) range (Table B5.0-2). This compares to maximum concentrations observed at Suncor's air quality monitoring stations that range from 820 to 1590 μg/m^3 (0.31 to 0.60 ppm). These hourly values are in excess of the provincial and federal guidelines. The 450 μg/m^3 guideline is predicted to be exceeded up to about 34 times per year (based on average emissions).

- **Suncor Incinerator:** Maximum predicted concentrations prior to SuperClaus are in the 698 to 1435 μg/m^3 (0.26 to 0.54) range (Table B5.0-2). With the implementation of SuperClaus, the corresponding maxima are reduced to the 338 to 573 μg/m^3 (0.13 to 0.22 ppm) range (Table B5.0-2). The values prior to SuperClaus are in excess of the provincial and federal hourly guidelines. The addition of SuperClaus reduces the maximum predicted values by a factor of two. Three exceedences of the 450 μg/m^3 guideline per year are predicted prior to SuperClaus and no exceedences are predicted after the implementation of SuperClaus (based on average emissions). Under upset conditions, with the simultaneous occurrence of adverse meteorological conditions, exceedences may result from the post SuperClaus operation.

- **Syncrude Main Stack:** Maximum SO_2 concentrations predicted by ISC3BE are in the 322 to 595 μg/m^3 (0.12 to 0.22 ppm) range (Table B5.0-2). The ISC3BE model predicts that one exceedence of the 450 μg/m^3 guideline could occur under upset conditions.

b) **Combined Operation**

- Relatively large SO_2 concentrations are predicted to occur on the elevated terrain to the east of Suncor (Muskeg Mountain) and to the southwest of Suncor (Thickwood Hills) (Figure B5.0-1). These maximum values result from the Suncor Powerhouse stack and are in excess of the 900 μg/m^3 Federal air quality objectives. Similarly, relatively large daily average maxima are predicted to occur in the same areas due to the operation of the Powerhouse stack (Figure 5.0-3).

- The combined operation of the three major sources (Suncor Powerhouse, Suncor Incinerator (after SuperClaus) and Syncrude Main) is predicted to result in a maximum of 37 to 49 hourly exceedences of the 450 μg/m^3 and 1 to 3 daily exceedences of the 150 μg/m^3 guideline. For the purposes of comparison, the observed number of hourly exceedences has varied from 9 to 41 hours per year. Similarly, the observed number of daily exceedences has varied from 2 to 9 days per year.

- Maximum annual average concentration (12 to 16 μg/m^3) from the combined operation of the continuous stacks are predicted to be less than the 30 μg/m^3 guideline Table B5.0-3). For the purposes of comparison, the background SO_2 concentration is in the 1 to 4 μg/m^3 range.

c) <u>Other Sources</u>

- Intermittent flaring can result in SO_2 concentrations that exceed the 450 and 900 $\mu g/m^3$ guidelines.

In summary, the largest SO_2 concentrations are associated with intermittent flaring which occurs on an intermittent basis and with the Suncor Powerhouse whose emissions are continuous.

B5.3 DEPOSITION

The uptake of sulphur compounds by surface features provides another measure of air quality. This uptake represents the removal of pollutants by vegetation, soil and water surfaces and is often referred to as deposition. Deposition can involve the action of precipitation **(wet deposition)** through two processes:

- **Washout** occurs when rainfall intercepts a plume and gases and particulates in the plume are dissolved or adsorbed in the rain droplet.

- **Rainout** occurs when particles in the plume acts as condensation nuclei on which rain droplets form.

Other deposition processes do not involve precipitation and are referred to as **dry deposition**. Dry deposition is the adsorption of gases and particulates directly to surfaces of vegetation, exposed soils and water bodies. In terms of potential acidification of terrestrial and/or aquatic systems, wet deposition delivers acidic compounds directly to the surface in short, intermittent rainfall events. In contrast, dry deposition relies on surface chemical or biological reactions to convert the deposited compounds to acidic species.

B5.3.1 Sulphate Equivalent Deposition

The Alberta Environment dispersion model ADEPT2 was used to estimate total deposition from the operation of the three main continuous SO_2 sources. The model was modified to predict higher dry deposition values based on more recent work undertaken by Alberta Research Council and Alberta Environment (Cheng and Angle 1993).

Table B5.0-4 shows the maximum predicted deposition values for the individual and combined operations of the sources. Because the individual maxima do not occur in the same location, the sum of wet plus dry and the sum of individual sources do not add up to the "TOTAL" and "Combined" values.

Figure B5.0-5 shows the total deposition contour pattern for the combined operation. The maximum value of 25.5 kg SO_4^{-2}/ha/a is predicted to occur about 26 km to the north-northwest of the Powerhouse stack. High values are also predicted to occur about 20 km to the south-southwest of the Powerhouse stack.

TABLE B5.0-4

MAXIMUM PREDICTED SULPHATE EQUIVALENT DEPOSITION

(kg SO_4^{-2}/ha/a)

	DRY	WET	TOTAL
Suncor Powerhouse	13.6	8.2	19.2
Suncor Incinerator	5.1	4.3	9.4
Syncrude Main stack	6.6	3.2	8.2
Combined	18.3	10.0	25.5

B5.3.2 Effective Acidity

The estimation of an Effective Acidity (EA) accounts for other compounds in precipitation that can either enhance or neutralize acidification. The following relationship was used to estimate the EA:

$$EA_{total} = \text{Background } (EA_{wet} + EA_{dry}) + \text{Combined } (EA_{wet} + EA_{dry})$$

The background wet and dry values based on Cree Lake observations are 0.05 and 0.08 kmol H^+ equivalent/ha/a, respectively (Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region). For the purposes of conservatism, the plant contribution, that is, Combined (EA_{wet} + EA_{dry}) was estimated from combined (wet + dry) sulphate deposition divided by a factor of 48. On this basis, the maximum estimated EA in the region is:

$$\begin{aligned} EA_{total}\,(\text{maximum}) &= 0.05 + 0.08 + (25.5/48) \\ &= 0.13 + 0.53 \\ &= 0.66 \text{ kmol } H^+ \text{ equivalent/ha/a.} \end{aligned}$$

Table B5.0-5 and Figure B5.0-6 identify preliminary deposition limits expressed in terms of Effective Acidity. The limits are specified for three sensitivity classes. About 9 to 27% of the area shown in Figure B5.0-6 falls within the limits defined for medium sensitivity ecosystems.

TABLE B5.0-5
AREAL EXTENT WHERE PREDICTED EA VALUES EXCEED PRELIMINARY DEPOSITION LIMIT RANGES

SENSITIVITY CLASS	RANGE ($kmol\ H^+/ha/a$)		AREA (km^2)	AREA (%)[a]
Low	Upper range	1.0	0	0
	Lower range	0.7	0	0
Medium	Upper range	0.4	1926	9
	Lower range	0.3	6033	27
High	Upper range	0.3	6033	27
	Lower range	0.1	22,400[a]	100

[a] Total area depicted in Figure B5.0-6 is 22,400 km^2.

The predicted deposition of sulphur compounds and the associated Effective Acidity (EA) values presented in this report are not comparable to those presented in previous assessments (i.e., the Syncrude Air Quality Assessment undertaken in 1992) because different methods were used. Specifically:

- Larger dry deposition velocities to be consistent with those used by Cheng and Angle (1993) were adopted.
- The Effective Acidity can be calculated in numerous ways (see Section 3.2.3, Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region). The methods used differ in the manner other compounds (both wet and dry) are incorporated.

The first change results in predicted dry depositions that are larger than those in the previous assessment, typically by a factor of 1.5 to 1.8 (Section 5.3 of this report). The second change also results in a larger dry deposition than the previous assessment by a factor of 1.2 to 2.0, depending on the chemistry of the region (Table 3.3, Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region). Assuming these factors are somewhat multiplicative, the predictions of EA provided in this assessment are expected to be 2 to 3 times that presented in the previous Syncrude assessment.

Until a methodology for predicting EA is selected by the technical and regulatory communities, it is difficult to interpret the model predictions in terms of environmental effects. For this reason, the deposition and EA contours presented in the figures should be regarded as providing an indication of relative spatial distributions and relative changes associated with differing emission scenarios.

B5.4 NO_X CONCENTRATIONS

There are numerous NO_x emission sources associated with the Suncor and Syncrude operations. Ambient NO_x concentrations associated with these sources were estimated using the SCREEN3 model. This model provides an efficient means of ranking individual sources in terms of their contribution to the overall ambient NO_x concentration and provides an indication of where maximum concentrations could occur.

B5.4.1 Maximum Hourly Average NO_x Concentrations

The maximum predicted NO_x concentrations associated with the continuous Suncor sources can be summarized as:

- The largest maximum NO_x concentration is associated with the operation of the Powerhouse stack (99 $\mu g/m^3$).
- The individual contribution from the other sources range from 2.6 to 15.1 $\mu g/m^3$.
- All maximum values are associated with daytime conditions (PG stability class A) and are predicted to occur between 0.4 and 1.3 km from the individual stacks.
- The sum of all the NO_x maxima is 251 $\mu g/m^3$. This sum, although not physically realistic due to temporal and spatial variations, indicates that the maximum NO_x values should be less than the 400 $\mu g/m^3$ guideline for NO_2.

The maximum predicted values do not incorporate building downwash effects. The effects of building downwash (where applicable) increase ambient concentrations nearer the source (i.e., within and downwind of the building wake). On this basis, the values for the shorter stacks are likely to be underestimated. The values presented are for NO_x and not NO_2. The air quality observations in Report 2 (Ambient Air Quality Observations in the Athabasca Oil Sands Region) indicated that for high NO_x values, the NO_2 is typically 20% of the total NO_x.

B5.4.2 Maximum Daily Average NO_x Concentrations

The SCREEN3 model can only predict maximum hourly average concentrations. Corresponding daily average values can be inferred from the hourly predictions using an empirical conversion factor. The SCREEN3 model documentation indicates maximum 24-hour average concentrations are generally about 0.4 ± 0.2 times the maximum one-hour average concentration

(U.S. EPA 1992). In contrast, AEP assumes a factor of 0.25 to convert hourly values to 24-hour values (Alberta Environmental Protection 1994). For dispersion amid irregular terrain, the U.S. EPA CTSCREEN model approach assumes the 24-hour average values are 0.15 the maximum one-hour values (Perry *et al.* 1990). The SO_2 predictions which were undertaken more rigorously support the use of a 0.2 conversion factor.

For conservative reasons, the 0.6 conversion factor was applied to the hourly predictions. For example, the application of 0.6 to the 251 $\mu g/m^3$ concentration mentioned in the previous section results in a corresponding 24-hour value of 150 $\mu g/m^3$. A 0.25 factor results in a 24-hour value of 63 $\mu g/m^3$. For the purposes of comparison, the 24-hour guideline is 200 $\mu g/m^3$.

B5.4.3 Maximum Annual Average NO_x Concentrations

The SCREEN approach recommends an empirical conversion factor of 0.08 $\pm$ 0.02 to estimate annual concentrations from the one-hour maximum. The regional SO_2 predictions suggest that a conversion factor of 0.01 could be used to convert maximum hourly values to maximum annual average concentrations. The U.S. EPA CTSCREEN model approach assumes a conversion factor of 0.03 for annual estimates (Perry *et al.* 1990).

The application of the more conservative 0.1 factor to the hourly value of 250 $\mu g/m^3$ results in a corresponding annual value of about 25 $\mu g/m^3$. This compares to the annual objective of 60 $\mu g/m^3$.

B5.4.4 Comment

In summary, screening and modelling indicate that the maximum NO_x concentrations will tend to occur within 1 km of the respective plant sites and specifically are likely to be confined to the plant site. The off-site NO_2 concentrations are likely to be well below the guideline values. This conclusion is somewhat confirmed with the air quality data collected by Syncrude (Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region). It should be noted, however, that the ambient data for NO_x are somewhat limited.

B5.5 PREDICTED AMBIENT CO CONCENTRATIONS

The major continuous sources of CO emissions from the Suncor plant are: the Powerhouse stack (14.1 t/d), the Incinerator stack (5.5 t/d), and the secondary combustion sources (0.85 t/d). As with the evaluation of NO_x emissions, the SCREEN3 model was used to estimate ambient CO concentrations for each source on an individual basis. The maximum predicted CO concentrations associated with the individual operation of each Suncor source ranges from 1 to 132 $\mu g/m^3$ as one-hour averages. These maxima are all within the 15,000 $\mu g/m^3$ one-hour guideline for CO.

B5.6 PARTICULATE CONCENTRATIONS

Ambient concentrations and depositions associated with particulate emissions from the Suncor Powerhouse stack were calculated as daily and annual averages. The following was found:

- Maximum daily average particulate concentrations is 8 $\mu g/m^3$. This value is well within total suspended particulate (TSP) daily guideline value (100 $\mu g/m^3$).
- Maximum annual average particulate concentrations is 0.3 $\mu g/m^3$. This value is well within the TSP annual guideline (60 $\mu g/m^3$).
- Maximum dry deposition of particulates is 3.1 kg/ha/a. Maximum wet deposition values (in excess of 100 kg/ha/a) are predicted at the source and decrease rapidly with increasing distance from the source.

The relatively low predictions associated with the Powerhouse stack emissions, when compared to some of the observations, suggest other significant contributors to ambient particulate concentrations observed in the region. These can include other industrial operations (i.e., conical burners), residential wood combustion, fugitive road dust and natural airborne dusts and pollens.

The particulate emissions from the Suncor Powerhouse stack contain metallic compounds. The maximum concentrations associated with these emissions were compared to Ontario Ambient

Air Quality Criteria since equivalent guidelines or criteria do not exist for Alberta. The comparison indicated that the maximum predicted levels are several orders of magnitude less than the Ontario criteria.

B5.7 TOTAL HYDROCARBON CONCENTRATIONS

A simple box model was used to predict ambient hydrocarbon concentrations in Fort McMurray and Fort MacKay that could occur from fugitive emissions. The box model approach assumes these emissions are transported up and down the Athabasca River Valley and the sides of the box are defined by the valley walls and the top is defined by an assumed inversion level. The results indicate the likely source of high ambient THC concentrations that have occurred in the Athabasca River Valley may be due to emissions from Suncor.

B5.8 CONCLUSIONS

Predictions from the dispersion model complement the conclusions associated with the review of the ambient air quality monitoring data (Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region). Both the modelling and monitoring indicate that the operation of the Suncor and Syncrude facilities has resulted in changes to the quality of the air downwind. Specifically, relatively high SO_2 concentrations have been observed and the model predictions indicate the Suncor Powerhouse as the main contributor to these values. The models also indicate that intermittent flaring can also result in relatively large SO_2 concentrations.

The modelling confirms that ambient concentrations of NO_x, CO and TSP associated with combustion sources should be within the respective guideline values.

The modelling also provides annual average concentration and deposition estimates that can be used to help select locations for future receptor monitoring programs.

Finally, the modelling assessment provides a tool by which air quality changes associated with future operations can be assessed. The effect of new sources and changes to existing sources can be evaluated and compared to the 1994/1995 baseline information.

C AIR QUALITY CHANGES

C1.0 PROPOSED EMISSIONS

The Fixed Plant and the Steepbank Mine expansion will be conducted in stages. The following provides a descriptive narrative that identifies changes that can result in air emissions released to the atmosphere. A more detailed project description is provided in Section C of the Steepbank Mine application.

C1.1 STAGE 1 FIXED PLANT EXPANSION

The Stage 1 Fixed Plant expansion will increase the production rate from the currently approved 79,500 bbl/cd to 87,000 bbl/cd. This increase can be undertaken without the addition of major equipment at the plant. The changes associated with the 1998 Stage 1 emission scenario are:

- The commissioning of the FGD system to reduce the SO_2 and particulate emissions from the coke-fired boilers in the Utilities plant (by about 75% and 85%, respectively). While this is not a part of the Stage 1 Expansion, the reduced emission scenario will be in place prior to the Stage 1 Expansion.
- The upgrading of one of the coke-fired boilers (Unit 2) to increase thermal efficiency from 81% to 85%. This upgrading will increase reliability as well as reduce NO_x emissions by about 15 to 20% due to low NO_x burner design (the use of overfired air).
- Three new trucks to increase haulage capacity will result in a corresponding increase in emissions from the mine fleet.
- Increased loading on the extraction plant (Plant 3) will increase VOC emissions in proportion to the load rate.
- No increases in process heater loading in the upgrading area as all incremental product will bypass further upgrading and be sold in a hydrotreated form.

Compared to the current (1994/1995) emission scenario, SO_2, NO_x and VOC emissions are expected to decrease, while CO_2 emissions are expected to increase.

C1.2 STAGE 2 FIXED PLANT EXPANSION

This expansion case includes the addition of new process technology and the addition of the Steepbank Mine. The second phase expansion is based on a production rate of 107,000 bbl/cd. The additional changes associated with this case include:

- Adding a vacuum distillation unit and installing a second diluent recovery unit will result in combustion products being vented to the atmosphere from two additional heater stacks.
- Integrating the existing vacuum unit and the proposed diluent recovery unit (DRU) with a heat exchanger to deliver heat to extraction plant process water. The associated improvement in energy efficiency and reduction in steam demand will decrease the emissions associated with Utilities.
- Upgrading the two remaining coke-fired boilers (Units 1 and 3) will result in increased efficiencies and decreased NO_x emissions.
- The extraction process will be undertaken at 50 to 55°C instead of the current 70 to 75°C. This will result in a reduced energy requirement.
- Reduction of continuous flaring by using the flare gases as a fuel.

Compared to the current (1994/1995) emission scenario, SO_2, NO_x and VOC emissions are expected to decrease, while CO_2 emissions are expected to increase.

C1.3 STEEPBANK MINE ACTIVITIES

The construction and operation of the Steepbank Mine will involve the following activities:

- Vegetation clearing will recover commercially salvageable timber. The waste material will be disposed of by burning which will result in particulate emissions to the atmosphere.
- Construction of mine access and haul roads will require the handling of granular resources. During dry, windy periods, these will result in fugitive dust emissions.
- Mining and transport of oil sands will be through a truck and shovel operation. Table C1.0-1 provides a summary of the number of shovels and trucks associated with the mine. Exhaust emissions from these units will result in NO_x, CO and CO_2 emissions, while tire/road surface interactions will result in fugitive dust emissions.

The truck and shovel operation will result in the dumping of the ore at a truck dump where the ore will be prepared for hydrotransport to the extraction plant. Three parallel process trains will be comprised of:

- Introduction of hydrotransport associated with the Steepbank Mine will result in a decommissioning of the extraction plant conditioning drums. The cyclofeeder/slurry transport will produce the required conditioning. This will reduce VOC emissions from Plant 3.
- An apron feeder and conveyor belt to deliver crushed ore from the surge bin to the cyclofeeder.
- A cyclofeeder to break down the oil sands to less than 5 cm in diameter and mix them with hot water to form a slurry. Associated recycle pumps provide the mechanical energy to assist in breaking down the oil sands clumps.
- The proposed Steepbank Mine Cyclofeeder will be serviced by a vent whose emissions are expected to be similar to the vents currently servicing Plant 3 and 4. Based on this similarity and changes in operating conditions, an initial estimate of THC emissions from this vent is 1 t/cd. When the unit is in service, measurements will be conducted to verify this value.

- Screens to remove particles in excess of 5 cm in diameter. The removed particles are sent to a rejection pile.
- Hydrotransport pumps and a slurry pipeline to transfer oil sands to the extraction plant. Due to turbulence in the pipeline, some initial separation of oil and sand takes place in the pipeline.

Due to active involvement of water in the above processes, the only fugitive dust emissions from the preparation for the hydrotransport of ore to the plant are expected to result from the ore sizer.

TABLE C1.0-1
SUMMARY OF LOAD AND HAUL EQUIPMENT ASSOCIATED WITH SUNCOR'S MINING OPERATIONS

YEAR	CABLE SHOVELS	HYDRAULIC SHOVELS	HAUL TRUCKS
2001	3	2	20
2004	4	2	22
2007	5	2	38
2009	5	2	25
2015	5	2	33
2020	5	2	38

The 2001 values given in Table C1.0-1 reflect the combined operation of the current mine and the proposed Steepbank Mine. For the purpose of comparison, the current operation is comprised of 3 cable shovels, 2 hydraulic shovels and 19 haul trucks. At the Suncor mine, the cable shovels are electric powered and the hydraulic shovels and haul trucks are diesel fuelled.

C1.4 TAILINGS MANAGEMENT

Over the lifetime of the existing mine and proposed Steepbank Mine, current tailings ponds will be reclaimed and new ones will be constructed. Table C1.0-2 provides an indication of anticipated status for current and proposed tailings ponds.

Tailings disposal for the Steepbank Mine will be based on the Consolidated Tailings (CT) process. This process involves the chemical treatment of a fine tailings/sand mixture with the addition of FGD plant gypsum. The process will start on Lease 86/17. While the end result of a CT process is a dry land reclamation, CT deposit areas (ponds) will be capped by a water surface while the ponds are in use.

Fugitive total hydrocarbon (THC) and total reduced sulphur (TRS) emissions result from the following tailings management activities:

- Relatively large THC and TRS emissions can result from the pond that receives Extraction Plant 4 discharge. This discharge is currently received by Pond 1, but by 2001 it will be received by Pond 2/3. Mitigation steps include improving the NRU (Naphtha Recovery Unit) recovery efficiency to reduce loss of hydrocarbons to the pond.
- All other ponds (except 1A) receive discharges from Extraction Plant 3. Relatively low THC and virtually no TRS emissions are associated with these ponds.
- The transfer of mature fine tailings (MFT) from Pond 1 or Pond 2/3 may expose MFT to the atmosphere at either the CT mixing tank or at the deposition site. Mitigation steps for possible THC emissions may include connecting the mixing tank to the site vapour collection system and ensuring the CT deposition is carried out under the water surface.

Based on extrapolation of current emission values and proportioning according to pond surface area and production, THC emissions from the ponds could increase by up to 30% when compared to the current case.

TABLE C1.0-2
STATUS OF SUNCOR'S TAILINGS POND
ESTIMATED THC EMISSION (t/d) ARE IN BRACKETS

POND	YEAR					LONG TERM
	1995	1998	2001	2010	2020	
1	Active[a] (3.1)	Active[a] (3.5)	Active (0.09)	Reclaimed (0)	Reclaimed (0)	Reclaimed
1A	Active[b] (0.09)	Active[b] (0.09)	Active[b] (0.09)	Active[b] (0.09)	Active[b] (0.09)	Reclaimed
2/3	Active[c] (0.25)	Active (0.25)	Active[a] (4.2)	Active[a] (4.2)	Active[a] (4.2)	Reclaimed
4	Active (0.06)	Active (0.06)	Active (0.06)	Active (0.06)	Active (0.06)	Reclaimed
5	Not operating (0)	Active (0.09)	Active (0.09)	Active (0.09)	Reclaimed (0)	Reclaimed
6	Not operating (0)	Not operating (0)	Active (0.09)	Active (0.09)	Reclaimed (0)	Reclaimed
7[d]	Not operating (0)	Not operating (0)	Not operating (0)	Active (0.09)	Active (0.09)	Reclaimed
8[d]	Not operating (0)	Not operating (0)	Not operating (0)	Active (0.09)	Active (0.09)	Reclaimed
Total (t/d)	3.5	4.0	4.6	4.7	4.5	

(a) Receives Extraction Plant 4 Discharge.
(b) Used to increase settling time of recycle water to reduce fines content.
(c) All other active ponds, unless indicated, receive Plant 3 Discharge.
(d) On Steepbank Mine.

C1.5 PROPOSED EMISSIONS

Tables C1.0-3 to C1.0-7 compare the changes in SO_2, NO_x, CO_2, THC and particulate emissions associated with the current scenario (1995) with those associated with the future scenarios (1998 to 2001). Comments specific for each emission accompany each table. Over the period 1995 (current) to 2001 (Stage 2 Expansion), the SO_2, THC and particulate emissions are expected to decrease significantly, while NO_x and CO_2 emissions are expected to remain fairly constant. Beyond the year 2001, the emissions should be the same as or less than those provided in Tables C1.0-3 to C1.0-7.

Table C1.0-8 compares the SO_2 emission parameters from the Powerhouse and FGD stacks for the current (1995) and future (1998 and 2001) scenarios. The scheduled uptime for the FGD is 95% (or 347 days per year). Of the 5% downtime (18 days per year), 7 days per year are expected to be planned for maintenance operations and this period will be scheduled as a contiguous block. The remaining 11 days per year are unplanned downtime events that will likely be randomly occurring throughout the year with differing durations. The average calendar day emission values provided in the table represent a composite associated with planned downtime, unplanned downtime and operational periods.

Table C1.0-9 compares the Incinerator stack emissions for the three scenarios. For abnormal periods, the SO_2 emissions were assumed to be 1.4 times the daily value divided by 24. This safety factor has been used frequently in Alberta to account for hour-by-hour variations that can occur in a sulphur recovery plant.

The 2001 operation scenario will require a vacuum distillation unit (Plant 25) to eliminate the cokers as a bottleneck and increase production by removing kerosene and gas-oil from the bitumen before it enters the cokers. Table C1.0-10 summarizes the two new Plant 25 heater stacks that will be a source of NO_x emissions.

TABLE C1.0-3
SO_2 EMISSIONS (t/cd) ASSOCIATED WITH CURRENT AND FUTURE SUNCOR OPERATIONS[a]

YEAR		1995	1998	2001
GROSS PRODUCTION	(bbl/cd)	77,500	87,000	107,000
	(m^3/cd)	12,231	13,832	17,012
Utilities[b]		214.6	27.2	30.4
Upgrading[c]		18.9	23.8	20.6
Total		233.5	51.0	51.0

(a) Based on Suncor estimates.
(b) From Utilities comprised of 3 coke-fired boilers and 3 gas-fired boilers.
(c) From the incinerator, continuous flaring and intermittent flaring.

Reduced SO_2 emissions from the utilities operation in 1988 and 2001 reflects the commissioning of the FGD plant. Increased SO_2 emissions from the upgrading in 1998 is based on increased throughput. The upgrading decrease in 2001 is based on the reduction of continuous flaring.

TABLE C1.0-4
NO_x EMISSIONS (t/cd) ASSOCIATED WITH CURRENT AND FUTURE SUNCOR OPERATIONS[a]

YEAR		1995	1998	2001
GROSS PRODUCTION	(bbl/cd)	77,500	87,000	107,000
	(m^3/cd)	12,231	13,832	17,012
Mine[b]		3.09	4.21	5.20
Utilities[c]		20.81	19.95	19.90
Upgrading[d]		13.18	12.73	10.85
Total		37.1	36.9	35.9

(a) Based on Suncor estimates.
(b) Diesel-fuelled mine vehicle fleet.
(c) From Utilities comprised of 3 coke-fired boilers and 3 gas-fired boilers.
(d) Combustion of natural gas and refinery gas and continuous flaring.

Increased NO_X emissions for the mine result from the increased number of shovels and haul trucks. Utilities plant emissions are relatively constant as increased energy efficiency is offset by increased production. Upgrading emissions decrease through better energy utilization. In summary, NO_x emissions remain relatively constant.

TABLE C1.0-5
CO_2 EMISSIONS (t/cd) ASSOCIATED WITH CURRENT AND FUTURE SUNCOR OPERATIONS[a]

YEAR		1995	1998	2001
GROSS PRODUCTION	(bbl/cd)	77,500	87,000	107,000
	(m^3/cd)	12,231	13,832	17,012
Mine[b]		208	276	341
Utilities[b]		6124	6225	6682
Upgrading[d]		3063	3039	2786
External Power[e]		248	855	-190
Total		9643	10,395	9819

(a) Based on Suncor estimates.
(b) Diesel-fuelled mine vehicle fleet.
(c) From Utilities comprised of 3 coke-fired boilers and 3 gas-fired boilers.
(d) Combustion of natural gas and refinery gas and continuous flaring.
(e) Import or export of electrical power.

The decreases and increases follow trends similar to that for NO_x for the same reasons. The external power represents the import (positive values) or export (negative values) of electrical power expressed as a CO_2 equivalent.

TABLE C1.0-6
HYDROCARBON EMISSIONS (t/cd) ASSOCIATED WITH CURRENT AND FUTURE SUNCOR OPERATIONS[a]

YEAR		1995	1998	2001
GROSS PRODUCTION	(bbl/cd)	77,500	87,000	107,000
	(m^3/cd)	12,231	13,832	17,012
Mine		0.2	0.3	0.3
Tailings Pond[b]		3.5	4.0	4.6
Tank Storage[c]		6.9	0.3	0.3
Extraction[d]		25.6	14.1	0.3
Upgrading[e]		6.3	6.9	7.7
Cyclofeeder System		0.0	0.0	1.0
Total		42.5	25.5	14.2

(a) Based on Suncor estimates.
(b) Primarily Pond 1 and Pond 2/3 (i.e., pond receiving Plant 4 tailings).
(c) North and South Tank Farms.
(d) Plants 3 and 4.
(e) Fugitive sources.

The 1995 estimates assume the VRU was not operating. The VRU recovers vapours from the South Tank Farm and Extraction Plant 4. The decrease in 2001 extraction emissions is based on decommissioning the Plant 3 conditioning drums as a result of hydrotransport.

TABLE C1.0-7
PARTICULATE MATTER EMISSIONS ASSOCIATED WITH CURRENT AND FUTURE SUNCOR OPERATIONS (COMBUSTION SOURCES ONLY).

YEAR		1995	1998	2001
GROSS PRODUCTION	(bbl/cd)	77,500	87,000	107,000
	(m^3/cd)	12,231	13,832	17,012
Mine[a]		0.18	0.25	0.30
Utilities[b]		6.30	0.95	0.95
Upgrading[a]		0.27	0.26	0.22
Total		6.75	1.46	1.47

(a) Future values were assumed to be proportional to NO_x emissions (Table C1.0-4).

The Powerhouse is serviced by electrostatic precipitators (ESP) that remove about 98% of the particulates generated by the combustion of coke. With the operation of the FGD process, additional particulate removal will occur when the flue gas is bubbled through the limestone slurry. Individual tests at Georgia Power's Plant Yates indicated a similar FGD system removed between 68 and 91% of the inlet particulate material. The average removal of 85% could provide a total effective particulate removal of up to 99.7% when the FGD unit is operational.

TABLE C1.0-8
EMISSION PARAMETERS ASSOCIATED WITH THE POWERHOUSE AND FGD STACKS

		POWERHOUSE STACK		FGD STACK	
		1995	1998/2001	1998	2001
Stack height	(m)	106.7	106.7	137.2	137.2
Stack diameter	(m)	5.79	5.79	7.01	7.01
Exit velocity	(m/s)	21.5	21.5	13.5	13.5
Exit temperature	(°C)	248	248	63	63
SO_2 emission					
Average	(t/sd)[a]	-	-	15.9	19.2
Average	(t/cd)	214.6	-	27.2	30.4
Planned	(t/sd)[b]	-	225	-	-
Unplanned	(t/sd)[c]	-	259	-	-
NO_x emission	(t/sd)	20.8	20.0	20.0	20.0
Particulate emission	(t/sd)	6.3	6.3	1.0	1.0

(a) 347 days per year.
(b) 7 days per year.
(c) 11 days per year.

TABLE C1.0-9
EMISSION PARAMETERS ASSOCIATED WITH THE SUNCOR INCINERATOR STACK

		1995	1998	2001
Stack height	(m)	106.7	106.7	106.7
Stack diameter	(m)	1.80	1.80	1.80
Exit velocity	(m/s)	20.3	20.3	20.3
Exit temperature	(°C)	478	478	478
SO_2 emission				
Average	(t/d)	15.8	19.8	20.2
Abnormal[a]	(t/h)	-	1.1	1.2

[a] Abnormal emissions were assumed to be 1.4 times the daily value divided by 24.

TABLE C1.0-10
PARAMETERS ASSOCIATED WITH THE PROPOSED SUNCOR PLANT 25 HEATER STACKS (2001)

UNIT		25F-1 DILUENT HEATER	25F-2 VACUUM HEATER
Heat duty	(mm BTU/h)	100.0	218.2
Fuel type		Refinery Gas	Refinery Gas
Fuel consumption	(10^3 m^3/d)	61.2	133.4
Efficiency	(%)	89	89
Excess air	(%)	10	10
Stack height	(m)	53.6	49.4
Stack diameter	(m)	2.44	2.87
Exit velocity	(m/s)	9.1	9.1
Exit temperature	(°C)	200	200
NO_x emission	(t/sd)	0.076	0.166
CO_2 Emission	(t/sd)	149	326

C1.6 SYNCRUDE SOURCES

Like Suncor, Syncrude proposes to increase the production capacity of their Mildred Lake plant over the next several years. This increase will result in changes to their emissions (Syncrude Canada, personal communication 1996). Table C1.0-11 compares the current main stack emissions with those associated with their expansion stages. For the purposes of future modelling, the Syncrude Main stack emissions were assumed to be 218 t/d.

These SO_2 emission values are on calendar day basis and actual values on any given day or hour may exceed these rates. On the average, Syncrude expects to increase production by about 40% in 2003 while the SO_2 emissions remain essentially the same.

TABLE C1.0-11

ANTICIPATED FUTURE EMISSIONS FROM SYNCRUDE

YEAR		**1995**	**1998**	**2001**	**2005**
STATUS		**CURRENT**	**STAGE I**	**STAGE II**	**STAGE III**
Production	(10^6 m^3/a)	12.6	13.5	15.5	17.6
	(bbl/cd)	217,500	223,000	256,800	303,800
SO_2	(t/cd)	207.4	218	208	218

C1.7 OTHER INDUSTRIAL SOURCES

The only future change for other industrial sources is the commissioning of the currently approved SOLV-EX Bitumount and Ruth Lake facilities. The emissions associated with these sources are identified in Table C1.0-12.

C1.8 TRANSPORTATION AND RESIDENTIAL SOURCES

No future changes were estimated for these sources.

C1.9 SUMMARY

Table C1.0-13 compares the current and proposed Suncor emissions and compares the proposed Suncor SO_2 emissions with other regional sources. On a regional basis, the SO_2 emissions are expected to decrease.

TABLE C1.0-12
SO_2 EMISSIONS ASSOCIATED WITH THE PROPOSED SOLV-EX MAIN STACKS

SOURCE		BITUMOUNT[a]	RUTH LAKE[b]
Base elevation	(m ASL)	284	326
Stack height	(m)	60	60
Stack diameter	(m)	1.35	1.50
Exit velocity	(m/s)	20.0	16.3
Exit temperature	(°C)	250	158
SO_2 emission			
Average	(t/d)	2.14	1.44
Abnormal	(t/d)	4.75	4.13

[a] The main stack servicing the incinerator and the sulphuric acid plant.
[b] The main stack servicing the sulphuric acid plant.

TABLE C1.0-13
PROPOSED REGIONAL EMISSION SUMMARY

Suncor Emissions

	1995	1998	2001
SO_2	233.5	51.0	51.0
NO_x	37.1	36.9	35.9
CO_2	9643	10,395	9819
CO	21.4	21.3[a]	20.7[a]
PM_c	6.75	1.46	1.47
THC	42.3	25.3	14.0
TRS	0.07	0.07	0.08

[a] Values prorated according to NO_x.

Regional SO_2 Emissions

	2001 SO_2
Suncor	51.0
Syncrude	218.0
Other Industries[a][b]	7.4
Transportation[a]	0.19
Residential Combustion[a]	0.005
Total 2001	277
Total 1995	449

[a] No changes assumed.

C2.0 DISPERSION MODEL PREDICTIONS

Hourly, daily and annual average SO_2 concentrations resulting from the operation of FGD system were estimated using the dispersion models discussed in Section B5.1. The calculations were undertaken based on emissions defined by periods when the FGD system was fully operational (FGD up) and on emissions defined by periods that combine when the FGD is both operating and not operating (FGD both). Specifically the "FGD up" emissions are 15.9 and 19.2

t/d for 1998 and 2001, respectively. The "FGD both" emissions are 27.2 and 30.4 t/d for 1998 and 2001, respectively.

C2.1 INDIVIDUAL STACK OPERATION

C2.1.1 One-Hour Average SO_2 Concentrations

Maximum one-hour average SO_2 concentrations were predicted using the SCREEN3 and ISC3BE models. The model predictions associated with the future (1998 and 2001) emission scenarios are summarized in Table C2.0-1. The comparison of the predicted results with those associated with the current emissions indicates:

- The FGD stack is predicted to decrease the maximum SO_2 concentrations associated with the current Powerhouse stack from 1346 to 2173 $\mu g/m^3$ (0.51 to 0.82 ppm) to 151 to 213 $\mu g/m^3$ (0.06 to 0.08 ppm) (Table B5.0-2 and C2.0-1).
- Increased production is predicted to slightly increase the maximum SO_2 concentrations associated with the Incinerator stack from 338 to 573 $\mu g/m^3$ (0.13 to 0.22 ppm) to 407 to 567 $\mu g/m^3$ (0.15 to 0.21 ppm).
- During periods when the FGD is not operating, maximum SO_2 concentrations associated with the Powerhouse stack is predicted to be in the 1216 to 1400 $\mu g/m^3$ (0.46 to 0.53 ppm) range. This is similar to that associated with the current Powerhouse operation.

TABLE C2.0-1
MAXIMUM ONE-HOUR AVERAGE SO_2 CONCENTRATIONS ASSOCIATED WITH THE PROPOSED (1998 AND 2001) SO_2 EMISSION SOURCES

SOURCE / SO_2 EMISSIONS		SCREEN3				ISC3BE					
		SO_2 CONCENTRATIONS				SO_2 CONCENTRATIONS				EXCEEDENCES	
		SO_2 ($\mu g/m^3$)	PG CLASS	WIND SPEED (m/s)	DISTANCE (km)	SO_2 ($\mu g/m^3$)	PG CLASS	WIND SPEED (m/s)	LOCATION (km/degrees)	N > 450 $\mu g/m^3$	LOCATION (km/degrees)
Stage 1 (1998)											
FGD Stack											
FGD up	(15.9 t/d)	213	A	1.5	1122	151	A	4.8	1.2 / 90	0	N/A
FGD both	(27.2 t/d)	365	A	1.5	1122	258	A	4.8	1.2 / 90	0	N/A
Incinerator											
Average	(19.8 t/d)	462	A	1.5	951	407	A	3.3	1.0 / 11	0	N/A
Abnormal	(1.15 t/h)	644	A	1.5	951	567	A	3.3	1.0 / 11	1	various
Powerhouse											
Planned	(225 t/d)	1381	A	2.5	1214	1216	E	0.6	23.6 / 216	32 (2)[a]	14.1 / 98
Unplanned	(259 t/d)	1590	A	2.5	1214	1400	E	0.6	23.6 / 216	41 (2)[a]	14.1 / 98
Stage 2 (2001)											
FGD Stack											
FGD up	(19.2 t/d)	257	A	1.5	1122	182	A	4.8	1.2 / 90	0	N/A
FGD both	(30.4 t/d)	407	A	1.5	1122	288	A	4.8	1.2 / 90	0	N/A
Incinerator											
Average	(20.2 t/d)	471	A	1.5	951	415	A	3.3	1.0 / 11	0	N/A
Abnormal	(1.18 t/h)	661	A	1.5	951	581	A	3.3	1.0 / 11	1	various
Powerhouse											
Planned	(225 t/d)	1381	A	2.5	1214	1216	E	0.6	23.6 / 216	32 (2)[a]	14.1 / 98
Unplanned	(259 t/d)	1590	A	2.5	1214	1400	E	0.6	23.6 / 216	41 (2)[a]	14.1 / 98
SOLV-EX											
Bitumount	(2.14 t/d)	120	A	1.0	0.8	69	E	1.4	40.3 / 353	0	N/A
Ruth Lake	(1.44 t/d)	97	A	1.0	0.8	151	E	1.0	4.5 / 261	0	N/A

[a] The values in the brackets are adjusted to account for a 95% FGD uptime.

Figure C2.0-1 shows the spatial concentration pattern expressed as a maximum one-hour average concentration. The results are shown from the FGD stack for the 2001 average emissions case (19.2 t/d). The maximum values are predicted to occur much closer to the stack. On the elevated regions around the plant, the maximum values are greater than 100 $\mu g/m^3$ (0.04 ppm).

C2.1.2 Daily Average SO_2 Concentrations

The ISC3BE model was used to predict maximum daily average SO_2 concentrations for the individual operation of SO_2 sources in the region. The model predictions associated with the current and future (1998 to 2001) emission scenarios are summarized in Table C2.0-2. The comparison of the predicted results with the current emission scenario indicate:

- The FGD stack is predicted to decrease the maximum daily SO_2 concentration from about 251 to 308 $\mu g/m^3$ (0.09 to 0.12 ppm) to 24 to 46 $\mu g/m^3$ (0.009 to 0.017 ppm).

- Increased production is predicted to increase the maximum SO_2 concentrations associated with the incinerator from about 104 $\mu g/m^3$ (0.04 ppm) to 117 to 120 $\mu g/m^3$ (0.05 ppm).

- During periods when the FGD is not operating, the maximum SO_2 concentrations associated with the Powerhouse stack is predicted to be in the 235 to 270 $\mu g/m^3$ (0.09 to 0.10 ppm) range. This is similar to that associated with the current Powerhouse operation.

Figure C2.0-2 shows the spatial concentration pattern expressed as a maximum one-day average concentration. The results are shown for the FGD stack for the 2001 emission case (19.2 t/d).

C2.1.3 Annual Average SO_2 Concentrations

The ISC3BE and ADEPT2 models were used to predict maximum annual average SO_2 concentrations from the individual operation of the SO_2 sources in the region. The model predictions associated with the future emission scenarios (1998 and 2001) are summarized respectively in Table C2.0-3. The comparison of the predicted results indicates:

- The FGD stack is predicted to decrease the maximum SO_2 concentrations associated with the current Powerhouse stack from 9 to 10 $\mu g/m^3$ (0.004 ppm) to about 2 $\mu g/m^3$ (0.001 ppm).
- Increased production is predicted to increase the maximum SO_2 concentrations associated with the incinerator from the 3 to 5 $\mu g/m^3$ range to the 4 to 6 $\mu g/m^3$ range (both are about 0.002 ppm).

The annual average concentrations resulting from the Powerhouse stack when the FGD is not operating was not calculated since the Powerhouse stack is expected to only operate in this mode about 18 days per year.

Figure C2.0-3 shows the spatial concentration patterns expressed as annual average concentrations. The results are shown for the FGD stack for the 2001 emission case (19.2 t/d). The predicted changes compare to the background values of 1 to 4 $\mu g/m^3$ observed at Cree Lake.

C2.2 COMBINED STACK OPERATION

The maximum SO_2 concentrations resulting from the combined operation of regional sources were evaluated using the parameters in Table C2.0-4. The table also shows the maximum hourly, daily and annual average SO_2 concentrations resulting from the combined operation of the identified sources.

C2.2.1 One-Hour Average SO_2 Concentrations

The maximum predicted hourly value of 437 to 454 $\mu g/m^3$ (~ 0.17 ppm) compares to that of 1279 to 1652 $\mu g/m^3$ (0.48 to 0.62 ppm) associated with the current emission scenario. The maximum values are predicted to decrease by almost a factor of three. In addition, the number of values that exceed the 450 $\mu g/m^3$ guideline are predicted to decrease from about 37 to 49 hours per year at the worst location to once per year. Figure C2.0-4 shows the maximum hourly average SO_2 concentrations with 2001 combined emission scenario. The highest values are predicted to occur over the elevated terrain towards Thickwood Hills and Muskeg Mountain.

TABLE C2.0-2
MAXIMUM 24-HOUR AVERAGE SO_2 CONCENTRATIONS ASSOCIATED WITH THE PROPOSED SUNCOR (1998 AND 2001) EMISSION SOURCES

SOURCE / SO_2 EMISSION		ISC3BE			
		SO_2 CONCENTRATION		EXCEEDENCES	
		SO_2 ($\mu g/m^3$)	LOCATION (km / degrees)	N > 150 $\mu g/m^3$	LOCATION (km / degrees)
Stage 1 (1998)					
FGD Stack					
FGD up	(15.9 t/d)	24	7.6 / 203	0	N/A
FGD both	(27.2 t/d)	41	7.6 / 203	0	N/A
Incinerator					
Average	(19.8 t/d)	117	2.2 / 207	0	N/A
Powerhouse					
Planned	(225 t/d)	235	25.6 / 231	1	various
Unplanned	(259 t/d)	270	25.6 / 231	1	various
Stage 2 (2001)					
FGD Stack					
FGD up	(19.2 t/d)	29	7.6 / 203	0	N/A
FGD both	(30.4 t/d)	46	7.6 / 203	0	N/A
Incinerator					
Average	(20.2 t/d)	120	2.2 / 207	0	N/A
Powerhouse					
Planned	(225 t/d)	235	25.6 / 231	1	various
Unplanned	(259 t/d)	270	25.6 / 231	1	various

TABLE C2.0-3
MAXIMUM ANNUAL AVERAGE SO_2 CONCENTRATIONS ASSOCIATED WITH THE PROPOSED (1998 AND 2001) EMISSION SOURCES

SOURCE / SO_2 EMISSION		ISC3BE		ADEPT2	
		SO_2 ($\mu g/m^3$)	LOCATION (km / degree)	SO_2 ($\mu g/m^3$)	LOCATION (km / degree)
Stage 1 (1998)					
FGD Stack					
FGD up	(15.9 t/d)	1.3	7.1 / 352	1.2	14.0 / 337
FGD both	(27.2 t/d)	2.2	7.1 / 352	2.1	14.0 / 337
Incinerator					
Average	(19.8 t/d)	6	2.2 / 207	3.8	8.8 / 337
Stage 2 (2001)					
FGD Stack					
FGD up	(19.2 t/d)	1.5	7.1 / 352	1.5	14.0 / 337
FGD both	(30.4 t/d)	2.4	7.1 / 352	2.3	14.0 / 337
Incinerator					
Average	(20.2 t/d)	6	2.2 / 207	3.9	8.8 / 337

TABLE C2.0-4
SO_2 EMISSIONS AND ISC3BE PREDICTIONS FOR THE PROPOSED 1998 AND 2001 OPERATIONS

SO_2 EMISSIONS (t/d)

STACK	1998	2001
Suncor FGD	15.8	19.2
Suncor Incinerator	19.8	20.2
Syncrude Main	218	218
SOLV-EX Bitumount	2.14	2.14
SOLV-EX Ruth Lake	1.44	1.44

ISC3BE MODEL PREDICTIONS

HOURLY AVERAGE		1998	2001
Maximum SO_2	(μg/m^3)	437	454
Stability Class		B	B
Wind Speed	(m/s)	2.4	2.4
Location	(km/degrees)	2.0 / 114	2.0 / 114
N > 450 μg/m^3		0	1
DAILY AVERAGE		**1998**	**2001**
Maximum SO_2	(μg/m^3)	125	129
Location	(km / degrees)	2.2 / 207	2.2 / 207
N > 150 μg/m^3		0	0
ANNUAL AVERAGE		**1998**	**2001**
Maximum SO_2	(μg/m^3)	7.7	7.9
Location	(km / degrees)	2.2 / 207	2.2 / 207

C2.2.2 Daily Average SO_2 Concentrations

The maximum predicted daily average value of 125 to 129 μg/m^3 (about 0.05 ppm) compares to that of 246 to 311 μg/m^3 (0.09 to 0.12 ppm) associated with the current emission scenario. The maximum values are predicted to decrease by a factor of two. Figure C2.0-5 shows the maximum daily average SO_2 concentrations associated with the 2001 combined emission scenario. The highest values are predicted to occur to the south of the FGD stack.

C2.2.3 Annual Average SO_2 Concentrations

The maximum predicted annual average value of about 8 $\mu g/m^3$ (0.003 ppm) compares to that of 12 to 16 $\mu g/m^3$ (0.005 to 0.006 ppm) associated with the current emission scenario. The maximum values are predicted to decrease by a factor of up to two. Figure C2.0-6 shows the annual average SO_2 concentrations associated with the 2001 combined emission scenario. The highest values are predicted to occur to the north of the FGD stack. For the purposes of comparison, the background SO_2 values observed at Cree Lake are about 1 to 4 $\mu g/m^3$.

C2.3 ANNUAL TOTAL DEPOSITION

The ADEPT2 model was used to predict wet and dry depositions from the new FGD stack and from the combined 1998 and 2001 operation scenarios. The RELMAP dry deposition velocities were used and the model predictions of maximum values provided in Table C2.0-5.

C2.3.1 FGD Stack

The ADEPT2 model was applied with the "FGD both" SO_2 emissions to account for periods when the FGD stack was not operating. The maximum predicted dry, wet and total depositions for the two emission scenarios are about 3.9, 2.4 and 5.8 kg SO_4^{-2}/ha/a, respectively. For the purpose of comparison, the associated maximum dry, wet and total depositions associated with the operation of the current Powerhouse stack are 13.6, 8.2 and 19.2 kg SO_4^{-2}/ha/a, respectively.

Figures C2.0-7 and C2.0-8 show the dry and wet deposition pattern associated with the operation of the FGD stack for the 2001 operation scenario (30.4 t/d). The maximum values are predicted to occur within 15 km of the plant (to the south-southwest, and the north-northwest for wet and dry deposition and in addition to the south-southeast for wet deposition).

TABLE C2.0-5
MAXIMUM DEPOSITION ASSOCIATED WITH THE FGD STACK AND THE COMBINED OPERATION OF THE REGIONAL SOURCES

Suncor FGD Stack Only (kg SO_4^{-2}/ha/a)

SCENARIO	1998	2001
SO_2 EMISSION (t/d)	27.2	30.4
Dry	3.5	3.9
Wet	2.1	2.4
Total	5.2	5.8

Total Deposition from All Regional Sources (kg SO_4^{-2}/ha/a)

SCENARIO	1998	2001
FGD	5.2	5.8
Incinerator	10.9	11.1
Main Stack	8.4	8.4
SOLV-EX Bitumount	4.3	4.3
SOLV-EX Ruth Lake	5.9	5.9
Combined	13.5	14.4

C2.3.2 Combined Operation

The effect of reducing the SO_2 emissions from the Suncor Utilities plant is significant. The FGD system, in particular, results in a reduction of the total deposition by a factor of more than three. The overall total deposition is reduced by a factor of 1.8 even though other sources have resulted in slight increases. Figure C2.0-9 shows the total (wet plus dry) deposition from the combined operation of stacks in the region for the 2001 emission case. The reduction of predicted deposition by a factor of nearly two that was presented in the table occurs over the receptor domain.

C2.4 EFFECTIVE ACIDITY

The predicted EA values can be compared to the preliminary deposition limits identified by Alberta Environmental Protection (Alberta Environment 1990). These values are 0.7 to 1.0 kmol equivalent H^+/ha/a for low sensitivity soils; 0.3 to 0.4 kmol equivalent H^+/ha/a for medium sensitivity soils; and 0.1 to 0.3 kmol equivalent H^+/ha/a for high sensitivity soils.

The maximum EA value associated with the 1995 emission scenario is 0.66 kmol equivalent H^+/ha/a (Section B5.3.2). For the 2001 emission scenario, this value is reduced to 0.43 kmol equivalent H^+/ha/a. Figure C2.0-10 shows the effective acidity contours from the combined operation of stacks in the region for the 2001 emission case. Table C2.0-6 compares the areas where each of the sensitivity criteria are exceeded. The effect of the FGD SO_2 reduction program reduces the area where 0.4 kmol H^+/ha/a is exceeded by a factor of 48. The region where the 0.3 kmol H^+/ha/a is exceeded is decreased by a factor of 3.9.

C2.5 PARTICULATE CONCENTRATIONS

The FGD SO_2 reduction program is expected to reduce the particulate emission associated with Suncor's Utilities from 6.3 t/d to 1 t/d. Table C2.0-7 shows the effect of reducing the particulate emissions from the operation of the Powerhouse. The maximum particulate concentrations are predicted to decrease from 7.5 μg/m^3 to 1.5 μg/m^3 as a daily average. For the purpose of comparison, the TSP (Total Suspended Particulate) guideline is 100 μg/m^3.

TABLE C2.0-6
AREAL EXTENT WHERE PREDICTED EA VALUES EXCEED PRELIMINARY DEPOSITION LIMIT RANGES

SENSITIVITY CLASS	RANGE (kmol H^+/ha/a)		AREA 1995 (km^2)	1995 (%)	2001 (km^2)	2001 (%)[a]
Low	Upper range	1.0	0	(0)	0	(0)
	Lower range	0.7	0	(0)	0	(0)
Medium	Upper range	0.4	1926	(9)	40	(0.2)
	Lower range	0.3	6033	(27)	1548	(7)
High	Upper range	0.3	6033	(27)	1548	(9)
	Lower range	0.1	22,400[a]	(100)	22,400	(100)

[a] Total area depicted in Figure C2.0-6 is 22 400 km^2.

TABLE C2.0-7
AMBIENT PARTICULATE CONCENTRATION AND DEPOSITION CHANGES ASSOCIATED WITH SUNCOR'S POWERHOUSE AND FGD STACKS

YEAR		1995	2001
STACK		**POWERHOUSE**	**FGD**
PARTICULATE EMISSIONS (t/d)		**6.3**	**1.0**
Daily concentration			
Maximum	(μg/m^3)	7.5	1.5
Location	(km/degrees)	25.6 / 231	7.6 / 203
Annual concentration			
Maximum	(μg/m^3)	0.26	0.09
Location	(km/degrees)	7.1 / 352	7.1 / 352
Annual dry deposition[(a)]			
Maximum	(kg/ha/a)	3.1	1.0
Location	(km/degrees)	7.1 / 352	7.1 / 352
Annual wet deposition[(a)(b)]			
Maximum	(kg/ha/a)	105	17
Location	(km/degrees)	0.2 / 180	0.2 / 180
Total deposition[(a)(b)]			
Maximum	(kg/ha/a)	105	17
Location	(km/degrees)	0.2 / 180	0.2 / 180

(a) Adjusted for a 12 months period; model simulation period is 20 months.
(b) Maximum value ~ 200 m from the stack; higher values are predicted to occur nearer the stack.

C2.6 HYDROCARBON CONCENTRATIONS

In spite of increases in THC emissions from the tailings ponds (because of more ponds) and the addition of a potential source (the cyclofeeder), the overall THC emissions are expected to decrease from the current 1995 value by 66%. Based on full operation of the VRU, the decrease in THC emissions from 1998 (25.2 t/d) to 2001 (14.0 t/d) is 44%.

With the assumption that elevated THC levels in Fort McMurray are due to Suncor; the concentration values given in Table B4.0-6 could also be expected to decrease by 66% (since the observations represented in Table B4.0-6 were prior to the commissioning of the VRU).

C3.0 GREENHOUSE GASES

The context of greenhouse gas emissions and the other human activities focuses on the change of global climate beyond the natural variation. Changes in climate can affect all aspects of life that include agriculture, forests, transportation, industry, commerce, insurance and financing. The specific concern with climate change is that mankind's activities may accelerate the change at a rate that we are incapable of adapting to. In the extreme, this change may not be reversible.

C3.1 BACKGROUND

The earth is constantly receiving energy from the sun in the form of short-wave electromagnetic radiation, that is energy whose wavelengths are near the visible portion of the solar spectrum (0.4 to 0.7 μm). Simultaneously, the earth is constantly radiating energy back into space in the form of long-wave electromagnetic radiation, that is energy whose wavelengths are in the infrared portion of the spectrum (5 to 20 μm). The relatively constant temperature of the earth's surface from year-to-year indicates a balance between the incoming short-wave radiation and the outgoing long-wave radiation.

The presence of certain gases in the atmosphere allow short-wave radiation to reach the surface of the earth but absorb the long-wave radiation from the earth. These gases are referred to as selective absorbers, or more commonly as greenhouse gases and they help maintain the earth's surface at a temperature that is habitable for humans, animals and plants. Specific greenhouse gases include:

- Carbon dioxide (CO_2) is an important component of the global carbon cycle that involves the carbon contained in the terrestrial biosphere (600 Gt of carbon), the atmosphere (750 Gt of carbon) and the oceans (39,000 Gt of carbon). The atmosphere exchanges about 600 Gt/a (of carbon) with living plants and about 90 Gt (of carbon) with the oceans.

On a global basis, human activities can affect the carbon balance, for example, deforestation over the past century has released about 100 Gt of carbon to the atmosphere. Fossil fuel use is estimated to contribute 6.3 Gt of carbon (or 23 Gt of CO_2) to the atmosphere each year.

On a global basis the carbon dioxide concentration appears to be increasing at 1.8 ppm per year (Hengeveld, 1995).

- Methane (CH_4), like CO_2, has a natural cycle in the atmosphere and is released from wetlands, rice paddies and the digestive tracts of termites, sheep and cattle. Industrial sources include the methane losses associated with fossil fuel extraction, transport and utilization; and garbage in landfill sites. As a greenhouse gas, on a molecule for molecule basis, methane is 21 times more effective than CO_2. On an emission basis, methane emissions are about 1% of those for CO_2.
- Nitrous oxide (N_2O) emissions result from agricultural use of fertilizers, biomass burning, industrial production of adipic acid, and vehicles equipped with catalytic converters. On a molecule for molecule basis, N_2O is 206 times more effective than CO_2. On an emission basis, N_2O emissions are less than 0.1% of those for CO_2.
- Other greenhouse gases include ozone (O_3), halocarbons (e.g., CFCs) and water vapour (H_2O). While these gases can lead to increases in temperature due to their similar selective absorption properties, their involvement in other processes may partly offset any warming effects.

On a global basis, the primary contributions to potential warming of the atmosphere are carbon dioxide (70%), methane (27%) and nitrous oxide (3%) (Hengeveld 1995). Other minor gases in the atmosphere that have the potential to form particulates (e.g., SO_2 to sulphates, NO_x to nitrates) as well as particulate emissions have the potential to offset the enhanced greenhouse effect.

Other human activities that affect climate on regional and global scales are:

- Land use changes affect the reflective and radiative properties of the earth's surface. Flooded lands, wet soils and industrial/residential areas absorb more energy than the natural regions. Deserts created by deforestation or overgrazing reflect more energy than the natural surfaces they replace.
- Industrial and agricultural release of aerosols (small particles) can reduce solar heating.
- Arctic haze can increase the absorption of the solar radiation and decrease the reflectivity of snow surfaces.
- While urban heat islands result in significant temperature increases on a local scale, collectively they are not expected to be significant on a global scale.
- Large scale water diversions and storage of water can have significant effects on regional climates.

In summary, there are a number of human activities that can affect climate on a regional to global basis. The release of greenhouse gases is one activity that may enhance global warming and lead to changes in climate.

C3.2 CLIMATE CHANGE

Past climate changes have been reviewed by examining historical temperature records (~ 100 years), written evidence (~ 1000 years), sediments, plant pollens (~ 10,000 years) or other geological indicators (~ 100,000 years). These historical trends have indicated:

- Extreme "ice-age" events have occurred at about 100,000 year intervals and little ice-ages at about 2500 year intervals.
- In Canada, the climate of 100 years ago was similar to that of today.
- Within the last 100 years, the Canadian climate has experienced a warming until the early 1940's then a slight cooling until the mid 1970's. This was followed by a warming continuing through the 1980's.

Future climate changes are based on mathematical climate models that predict the 0.5°C temperature increase observed over the last 100 years. This observation and prediction are, however, within the natural variability of climate changes. The models, while useful tools, do incorporate uncertainties due to the simplification of climate processes and of the earth's relief including bathymetry of the oceans.

C3.3 GLOBAL RESPONSE

The effects of global warming on climate cover every aspect of mankind and include the following:

- Changes in precipitation and temperature patterns will affect natural ecosystems as well as agricultural productivity.
- Changes in atmospheric circulation patterns may lead to the more frequent occurrence of unfavourable meteorological conditions (i.e., droughts, storms, cold periods, floods).
- Increases in sea-levels could adversely affect coastal regions.

The direction and magnitude of the changes are largely unknown, they could be negligible, positive or negative on a global basis. Changes in the regional distribution climate parameters could have adverse consequences in already marginal areas.

If climate changes are enhanced by human activities, and this change has potential undesirable effects, it is in the best interest to control these human activities. Given the global nature of the effects and the differences of world nations, the recognition and adoption of a collective approach presents a number of challenges:

- Dealing with scientific uncertainty involves risk decisions that result in either actions that are taken for something that would not happen or actions that are not taken for something that will happen.
- International consensus has to address an element of fairness for both industrialized and non-industrialized values.
- For actions to be effective, the regulators, as well as the public, have to accept and commit to actions that may have lifestyle implications.

In spite of these challenges, a number of international commitments have been undertaken:

- In 1977, the World Meteorological Organization (WMO) founded the World Climate Program (WCP) to promote and co-ordinate international research on global climate processes.
- In 1988, WMO and the United Nations Environment Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) to provide scientific knowledge to the policy community.
- In 1988, The World Conference on the Changing Atmosphere recommended that global CO_2 levels be reduced by 20% of the 1988 levels by the year 2005.
- In 1992, a Framework Convention on Climate Change (FCCC) was approved at the UN Conference on Environment and Development held in Rio de Janeiro. Participating industrial nations committed to limiting all greenhouse gases to 1990 levels by the 2000.

Canada, in particular, has been active in responding to climate change and greenhouse gas emissions through the following programs:

- The Canadian Climate Program (CCP) has initiated a number of climate related research programs.
- Background monitoring stations located at Alert (N.W.T.), Sable Island (N.S.), Fraserdale (Ont.) and Estavan Point (B.C.), collect CO_2 measurements as part of the WMO network of background stations.
- On December 1992, Canada became the eighth country to ratify the FCCC and as such, has the commitment to stabilize greenhouse gas emissions at 1990 levels by the year 2000.

In response to the FCCC commitment, the Energy and Environment Ministers in Canada tabled a National Action Program on Climate Change. The objective of the program is to set *"the course of meeting Canada's convention commitments in the areas of climate change, mitigation, adaptation, research and education and international cooperation"*. One mitigation activity is the Voluntary Climate Challenge and Registry Program. The objective of this program is to *"stimulate a prompt response to reducing or offsetting greenhouse gas emissions"*. The Voluntary Challenge program was endorsed by federal, provincial and territorial environment ministers in late 1994. In January 1995, the Government of Canada and the Canadian Association of Petroleum Producers (CAPP) signed a Memorandum of Understanding that establishes a framework to develop strategies to reduce greenhouse gas emissions.

C3.4 SUNCOR RESPONSE

There are two motivations to reduce greenhouse gas emissions:

- Energy and resource conservation measures ensure the more efficient use of available resources. The measure of efficiency can be expressed as an emission per output of product. Table C3.0-1 compares the efficiency of the Suncor operations expressed in tonnes of CO_2 per thousand barrels of hydrocarbon product.
- CO_2 (and CH_4) reductions from an absolute sense to meet Canada's commitment to reducing CO_2 emissions by the year 2000 to those of 1990. The maintenance or future decrease in these emissions may help reduce potential climate change. Table C3.0-1 compares the total equivalent CO_2 emissions associated with Suncor's operations.

The results in Table C3.0-1 indicate a significant improvement in efficiencies over the 1990 reference year. The absolute emission for 1990 to 2001, however, are estimated to increase from 9312 t/d to 9819 t/d (a 5.4% increase).

Suncor Inc. and its three operating groups participate in the Voluntary Climate Challenge and Registry Program and forms part of Canada's Natural Action Program on Climate Change (Suncor Inc. 1995). The action plan indicated that CO_2 emissions from the oil sands group could increase by 18.6% for the year 2000 over the 1990 base values. The numbers (i.e., 5.4% increase) presented in Table C3.0-1 are based on more recent information. While these numbers have not decreased in the absolute sense, Suncor is committed "to research opportunities for greater environmental gains in the years ahead and will continue to report on its progress in fulfilling its commitments".

TABLE C3.0-1
COMPARISON OF SUNCOR'S CO_2 EMISSIONS FOR 1990, 1995, 1998 AND 2001

YEAR		1990	1995	1998	2001
Gross Production	(bbls/d)	58,900	77,500	87,000	107,000
CO_2 Emissions	(t/d)	9312	9643	10,395	9819
CO_2/Production	(t/1000 bbls)	158.0	124.4	119.5	98.1

D AIR QUALITY IMPACT ANALYSIS

D1.0 IMPACT CLASSIFICATION APPROACH

Table D1.0-1 outlines an impact classification approach used for the Steepbank Mine assessment. The criteria have been adjusted to reflect air quality assessment issues. The criteria associated with "severity" relate to ambient air quality concentrations. When the term is applied to other parameters that are quantifiable, the magnitude of any increases or decreases are given explicitly. The criteria associated with duration likewise refers to ambient air quality concentrations.

TABLE D1.0-1
IMPACT CLASSIFICATION CRITERIA

TERM	ATTRIBUTE	CRITERIA
Direction	Positive	Socially favourable
	Negative	Socially unfavourable
Severity/Magnitude	Low	Near background conditions
	Moderate	Less than ambient guidelines
	High	Above ambient guidelines
Duration	Short-term	Acute (1 hour to 1 day)
	Medium-term	Chronic (annual)
	Plant-life	When fixed plant and mine are operating
	Long-term	More than 30 years
Geographic Extent	Local	Steepbank Mine site
	Regional	Within 60 km
	Global	Global

These terms can be synthesized into an overall degree of concern:

Low	Any impact that is restricted to local areas, is low in severity, or is a moderate impact of short-term duration.
Moderate	Any moderate impact that does not extend beyond the regional area and is not of long-term duration.
High	A moderate or high impact that extends beyond the regional area and is of long-term duration.

D2.0 IMPACT ANALYSIS

D2.1 SUNCOR SOURCE CHARACTERIZATION

"Specify the type, volume and source of air emissions from each component of the integrated operation including fugitive emissions. Identify and describe emission sources at normal operating conditions and during abnormal or upset conditions. Compare the proposed air emissions to the previous air emission levels from the Suncor plant."

"Summarize current emission levels and anticipated regional levels of key contaminants, identifying the major point sources of emissions."

"What are emissions from the hydrotransport building?"

"Are there additional gas emissions from treatment wetlands?"

"What will be the stack emissions including SO_2, NO_x and VOC from operational flaring?"

Response

Details of air emissions from Suncor's current operation are provided in Report 1 (Sources of Atmospheric Emissions in the Athabasca Oil Sands Region) and anticipated changes associated with the proposed integrated operation are provided in Section C of this report. Table D2.0-1 provides an overall summary of current (1995) and proposed (1998 and 2001) emissions from the facility. For years beyond 2001, the emissions are expected to be the same as or less than those provided for 2001. The results in Table D2.0-1 indicate a significant decrease in SO_2 emissions, relatively constant NO_x and CO_2 emissions and significant decreases in THC and PM_c emissions.

TABLE D2.0-1

SUMMARY OF AIR EMISSIONS (t/d) FROM SUNCOR CURRENT AND PROPOSED OPERATIONS

SOURCE	TYPE	SO_2			NO_x			CO_2			THC			TRS			PM[e]		
		1995	1998	2001	1995	1998	2001	1995	1998	2001	1995[c]	1998[d]	2001	1995	1998	2001	1995	1998	2001
Mine	Vehicle Fleet	0.3	0.4[a]	0.5[a]	3.1	4.2	5.2	208	276	341	0.2	0.3	0.3	0	0	0	0.2	0.3	0.3
	Cyclofeeder	0	0	0	0	0	0	0	0	0	0	0	1.0	0	0	0.1	0	0	0
Utilities	Powerhouse/ FGD Stacks	214.6	27.2	30.4	20.8	20.0	19.9	6124	6225	6682	0	0	0	0	0	0	6.3	1.0	1.0
Upgrading	Incinerator/ secondary stacks/ flaring	18.9	23.8	20.6	13.2	12.7[b]	10.9[b]	3063	3039	2786	0	0	0	0.6	0.6	0.6	0.3	0.3	0.2
	Fugitive Sources	0	0	0	0	0	0	0	0	0	6.3[f]	6.9[f]	7.7[f]	0	0	0	0	0	0
Tailings Ponds	Area	0	0	0	0	0	0	0	0	0	3.5	4.0	4.6[g]	0.07	0.07	0.07	0	0	0
Tank Storage	Tank Vents	0	0	0	0	0	0	0	0	0	6.9	0.3	0.3	0	0	0	0	0	0
Extraction	Plant Vents	0	0	0	0	0	0	0	0	0	25.6	14.1	0.3	0.04	0.04	0.04	0	0	0
External Power	Electrical	-	-	-	-	-	-	248	855	-190	-	-	-	-	-	-	-	-	-
Total	All	233.8	51.4	51.5	37.1	36.9	35.9	9643	10 395	9819	42.5	25.6	14.2	0.7	0.7	0.8	6.8	1.5	1.5

(a) SO_2 emissions were prorated according to NO_x.
(b) The larger Suncor estimates are provided in the table.
(c) Assumes Vapour Recovery Unit (VRU) is not operating.
(d) Assumes VRU is operating.
(e) Only from combustion sources.
(f) Fugitive emission estimates.
(g) Fugitive THC emission estimates for 2010 and 2020 are 4.7 and 4.5 t/d, respectively.

Abnormal conditions that affect emissions include the following:

- **Intermittent flaring (both planned and unplanned)** occurs about 90 days each year. During these periods, the SO_2 emissions associated with typical flaring events range from 0.1 to 80 t/event.

- **Upset in the Sulphur Recovery plant.** The normal SO_2 emission rates are expected to be in the 18 to 20 t/d range. Normal hour-by-hour variations could cause SO_2 emissions of up to 1.2 t/h (which is equivalent to an emission rate of 28 t/d).

- **Periods when FGD is down (both planned and unplanned).** Maximum SO_2 emissions from the Powerhouse under planned downtime conditions are expected to be 225 t/d. For unplanned downtime conditions, the maximum SO_2 emission rate could be as high as 259 t/d. These values are similar to those associated with the current 1995 operation. For the purposes of comparison, the expected FGD stack emissions are 19.2 t/d ("FGD up") and 30.4 t/d ("FGD both"), respectively.

Every effort is made to reduce unplanned abnormal events and to minimize the duration of planned abnormal events.

Impact Classification

While emissions in themselves are not an impact, the classification approach in Section D1.0 was used as a basis for comparing 1995 with 2001 emission levels provided in Table D2.0-1. The application of this approach is given in Table D2.0-2. Reductions were classified as positive, and values that remain essentially constant (less than 10% change) were classified as neutral. The duration was taken as the life of the integrated mine and plant. As the emissions are from the plant and mine site, they are defined as local.

TABLE D2.0-2

IMPACT ANALYSIS FOR CHANGES IN SUNCOR EMISSIONS

	SO_2	NO_x	CO_2	THC	PM
Direction	Positive	Neutral	Neutral	Positive	Positive
Severity/Magnitude	78% Reduction	3% Reduction	2% Increase	68% Reduction	73% Reduction
Duration	Plant-life	Plant-life	Plant-life	Plant-life	Plant-life
Geographical extent	Local	Local	Local	Local	Local

Recommendations

A number of the emission sources have been extensively monitored while others are based on the use of emission factors. The application of U.S. EPA emission factors results in lower NO_x emissions from upgrading secondary stacks than the factors used by Suncor. Selective stack surveys can confirm which values should be used. The estimate of fugitive hydrocarbon emissions from upgrading is based on emission factors. A more direct quantification method would help confirm the numbers reported in the table. Periodic monitoring would help obtain a better understanding of some of the emission sources. No estimates have been undertaken for fugitive sources of surface particulates from traffic and mining operations.

In summary, the operation of the plant in 2001 will result in reduced SO_2, THC and PM emissions when compared to current (1995) operations. NO_x and CO_2 emissions are expected to remain essentially constant. The accompanying increase in production over the same period is from the current 77,500 bbl/d to 107,000 bbl/d.

TABLE D2.0-3

CURRENT AND PROPOSED REGIONAL EMISSIONS (t/d)

SOURCES (CURRENT)

EMISSION	SUNCOR	SYNCRUDE (1995)	OTHER INDUSTRY [a]	TRAFFIC/ RESIDENTIAL	TOTAL
SO_2	233.5	207.4	0.1	0.2	441.2
NO_x	37.1	31.7	0.50	1.3	70.6
CO_2	9643	23,733	1101	587	35,064
THC	42.3	17.2	3.0	2.3	64.8
PM_c	6.8	13.9	0.3	2.9	23.9

[a] Excludes the currently approved Solv-Ex Bitumount and Ruth Lake facilites.

SOURCES (PROPOSED)

EMISSION	SUNCOR (1995)	SUNCOR (2001)	OTHER[a] INDUSTRY
SO_2	51.4	51.5	7.4
NO_x	37.1	35.9	2.8
CO_2	10,395	9819	3651
THC	25.6	14.2	5.5
PM_c	1.5	1.5	2.3

[a] Includes the Solv-Ex Bitumount and Ruth Lake facilities.

D2.2 REGIONAL SOURCE CHARACTERIZATION

"Summarize current emission levels and anticipated regional emission levels of key contaminants, identifying the major point sources of emissions."

"Identification of emissions from current Suncor sources, other sources in the airshed and proposed changes associated with Suncor's Steepbank Mine and Fixed Plant Expansion. Fugitive and intermittent sources need to be identified."

Response

Additional sources in the area include: Syncrude's Mildred Lake facility, other industrial sources and traffic/residential sources. The identification of these sources and the estimation of associated emissions are presented in Report 1: Sources of Atmospheric Emissions in the Athabasca Oil Sands Region. Table D2.0-3 compares current regional emissions.

The "other industry" emissions include the AOSTRA UTF operations, Northland Forest Products conical burner and the Fort McMurray Hospital incinerator. It is clear that Suncor and Syncrude contribute most of these emissions in the region. The community emission sources (traffic/residential), even though they are relatively small, should not be ignored with respect to air quality and community health. This is because low-level community sources can have adverse impacts on local air quality.

The proposed emission sources are shown for Suncor and the other industry values that result from the addition of the proposed SOLV-EX Bitumount and Ruth Lake facilities. Syncrude main stack emissions are expected to be around 218 t/d as an annual average. Overall the SO_2 emission in the region is expected to drop from the total current value of about 450 to 480 t/d to a future value of about 280 t/d.

Impact Classification

Table D2.0-4 applies the impact classification approach to the proposed SO_2 emission values using the same criteria as in Section D2.2. The net effect from a regional basis is a reduction in SO_2 emissions.

TABLE D2.0-4

IMPACT ANALYSIS FOR CHANGES IN REGIONAL SO_2 EMISSIONS

	SO_2
Direction	Positive
Severity/Magnitude	40% Reduction
Duration	Plant-life
Geographic Extent	Regional

Recommendations

A large reliance was placed on emission factors for the smaller sources in the region. While the values indicate that community sources are relative small, additional efforts may be warranted to refine these estimates to help assess local air quality and health interactions. The regional estimates provided do not account for natural sources that include combustion emissions from forest fires as well as hydrocarbon (THC) emissions from vegetation. A common database format would assist in providing a detailed ongoing inventory that would include all sources.

D2.3 FUGITIVE DUST EMISSIONS

"Fugitive dust emissions from sources such as coke storage piles, overburden dumps, tailings ponds and gypsum ponds."

"Will there be impacts from fugitive dust from coke piles, overburden dumps and tailings ponds?"

"Will there be gypsum dusting problems?"

"Will there be impacts from greater sulphur stockpiling?"

Response

Fugitive dust emissions from these sources have not been quantified. The following discussions address each source qualitatively.

- **Coke Storage Pile.** Excess coke that cannot be used by the Powerhouse is stored in a stockpile. The production of coke is proportional to the supply of energy produced by the Powerhouse. The current coke stockpile is a source of fugitive dust emissions as well as products of combustion from sporadic fires in the stockpile. Suncor is investigating long-term handling and storage options for the excess coke. The current stockpile will be full in 1999. A new location (yet to be determined) will be prepared at that time. Coke storage areas will be capped for final reclamation.

- **Haul Roads.** Mine traffic along haul roads can result in fugitive dust under dry, windy conditions. Suncor waters the roads in high traffic areas to reduce dust emissions on an as required basis.

- **Tailings Ponds.** There will be an increase in the total active pond area associated with the Steepbank Mine. The exterior edges of the tailings pond dykes are reclaimed and revegetated as close to the top as possible to reduce the occurrence of blowing sand. The top of the dykes and the interior beaches, however, are not reclaimed during active pond operation and as such, these sources will continue to produce blowing sand under windy conditions.

- **Gypsum Ponds.** The gypsum pond will service the new FGD system. The gypsum pond will be initially capped with water which will minimize fugitive dust. As the gypsum surface is expected to be smooth and hard, fugitive dust is not expected. Should the gypsum from the pond be reclaimed, Suncor will monitor dust production and apply wetting techniques, as required.

- **Sulphur Storage.** Suncor does not currently store sulphur in block form on-site and does not have future plans to do so. All produced sulphur is shipped off-site in liquid form.

Impact Classification

Table D2.0-5 summarizes the classification scheme as applied to the fugitive emissions. Until the coke stockpile is capped, the rating is medium; after the pile has been capped, the rating is low.

TABLE D2.0-5
IMPACT ANALYSIS FOR FUGITIVE DUST EMISSIONS

	COKE STORAGE PILE	HAUL ROADS	TAILINGS PONDS	GYPSUM PONDS	SULPHUR STORAGE	OVERBURDEN DUMPS
Direction	positive	neutral	negative	negative	neutral	neutral
Severity/magnitude	medium/low	low	medium	low	none	low
Duration	short-term	short-term	short-term	short-term	-	short-term
Geographical extent	local	local	local	local	-	local

D2.4 COMBUSTION PARTICULATE EMISSIONS

"Will particulates and heavy metals be addressed, e.g. $(NH_4)_2 SO_4$?"

Response

Particulates released from combustion sources contain heavy metals. The combustion of coke results in particulates with the accompanying heavy metals being entrained into the exhaust gases where an electrostatic precipitator removes a nominal 98% of the particulates produced. The remaining 2% is vented into the atmosphere. Particulates from the flue gas were collected and analyzed for metal content in 1985. A dispersion model was used to estimate maximum ground-level metal concentrations and these were compared to ambient guidelines. As Alberta does not have guidelines for ambient metal concentrations, the Ontario values were used. The comparison indicated that predicted ambient metal concentrations were several orders of magnitude lower than the guideline (Report 4: Ambient Air Quality Predictions in the Athabasca Oil Sands Region).

The operation of the proposed FGD stack provides the benefit for further reduction of particulate emissions. Specifically, similar FGD systems have demonstrated a particulate removal efficiency of 85%. This type of removal efficiently is expected to reduce the particulate emissions from 6.3 to 1.0 t/d. The metal emissions are expected to experience a similar reduction. As the ambient metal emissions were much less than the guidelines they were compared with, the modelling was not redone with the lower emissions.

Impact Classification

The impact classification associated with the emission and associated ambient concentrations of particulates and heavy metals from the operation of the Powerhouse is given in Table D2.0-6. When the FGD is down, the particulate and metal emissions will remain the same as that associated with current emissions. Overall, the degree of concern is viewed as Low.

Recommendations

Particulate concentrations in the flue gas are measured routinely by the manual stack surveys. The metal content associated with the Suncor Powerhouse emissions were obtained from measurements conducted in 1995. When the FGD is commissioned, it is recommended that particulate measurements be made both upstream and downstream of the FGD system to confirm the enhanced recovery of particulates. It is furthermore recommended that both the upstream and downstream particulate be analyzed for metals and non-metals to confirm the values used in this assessment. Furthermore, monitoring should be undertaken to determine changes to plume visibility that may result from changes in the particulate emission profile that can occur through reactions in the stack.

Though not specified under the issues statement, particulate matter 10 μm in diameter or less (PM_{10}) is a potential air quality parameter of concern from a human health perspective. Specifically, no measurements of this parameter are undertaken in either Fort McMurray or Fort MacKay. It is unlikely that combustion sources from either Suncor or Syncrude result in appreciable contributions to PM_{10} in these communities. The likely source, especially in Fort McMurray, is residential wood combustion.

TABLE D2.0-6
IMPACT ANALYSIS FOR PARTICULATES AND HEAVY METALS EMITTED BY THE POWERHOUSE STACK

	EMISSION	AMBIENT
Direction	Positive	Positive
Severity/Magnitude	85% Reduction	Low
Duration	Plant-Life	Annual
Geographic Extent	Local	Regional

D2.5 CLIMATE

"Discuss the baseline climatic and air quality conditions. Emphasize those parameters that have the potential to influence the success of mitigation measures and reclamation."

Response

Suncor enhanced their meteorological monitoring program at the Mannix and Lower Camp ambient air quality monitoring sites. The instrumentation at these sites was selected to provide a better understanding of the air flow and atmospheric turbulence and the associated influence on air quality. The meteorological data that were collected by this program were reviewed in Report 3 (Meteorology Observations in the Athabasca Oil Sands Region) and a summary is provided in Section 4 of this impact analysis report.

Suncor does not maintain a meteorological station for the purpose of collecting precipitation data in support of a reclamation program. Precipitation data can exhibit considerable year-to-year variability and a short data record may not provide the data extremes required for reclamation design and planning.

Suncor and its staff have considerable reclamation experience in the area and understand the moisture requirements to revegetate a surface and the precipitation intensities that could result in slope erosion. The reclamation plan considers climatological factors as well as soil building materials. Specifically, the limitations of the short growing season, and cold dry winters are well known to Suncor staff.

Impact Analysis

None required.

D2.6 MODELLING

"Model regional air quality including consideration of terrain features. Justify the use of selected dispersion model(s) and identify any short-comings of the models or constraints to their findings. Address both local and regional effects and assess their implications."

Response

Four models were used to evaluate ambient air quality changes in the region. The selection and evaluation of the models were discussed in some detail in Report 4: Ambient Air Quality Predictions in the Athabasca Oil Sands Region. The models and their limitations are also discussed in Section B5.1 of this report. Briefly:

- The ISC3BE model was used to predict SO_2 concentrations and particulate concentrations and depositions. When compared to SO_2 observations, the model was found to favourably predict the magnitude and the observed trends.

- The SCREEN3 model was used to predict SO_2, NO_x and CO concentrations. The model predictions were similar to those predicted by ISC3BE. The strength of SCREEN3 lay in its simplicity and thus can be applied efficiently to other sources.

- The ADEPT2 model was used to predict annual average deposition of sulphur compounds. This model, developed by Alberta Environment, has been applied to numerous facilities in Western Canada. While the individual components or modules of the model are based on our understanding of physical and chemical processes, the model predictions have not been compared to observations because of the difficulty in obtaining independent measurements of dry deposition.

- A simple box model was applied to fugitive hydrocarbons. The model was able to provide a first order estimate of concentrations that could occur at upvalley and downvalley locations.

The general limitations of dispersion models that were discussed in Section B5.1 of this report apply to the selected models. In particular, model physics as a simplification of real world processes and the model predictions are influenced by the input parameters that include information on sources, meteorology and the ambient air quality data used to evaluate the model. It is because of these limitations that a considerable effort was expended to characterize sources (Report 1: Sources of Atmospheric Emissions in the Athabasca Oil Sands Region), observed air quality (Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region) and meteorology (Report 3: Meteorology Observations in the Athabasca Oil Sands Region) prior to undertaking the model selection and application to determine current conditions (Report 4: Ambient Air Quality Predictions in the Athabasca Oil Sands Region).

Impact Analysis

None required.

Recommendations

There is a shift to move away from the current models based on PG stability classes. The U.S. EPA has been in the process of developing a new model AERMOD to replace ISCST3. When the development is completed, the application of that and other recent model developments to the Athabasca oil sands area can be reviewed.

D2.7 EXISTING AIR QUALITY

"Characterize the existing air quality and identify air quality parameters of concern. Review current emission sources and anticipated future development scenarios within the Study Area. Discuss appropriate air quality parameters such as SO_2, H_2S, total hydrocarbons NO_x, VOC's, ground-level ozone, as well as, wind direction, wind speed, temperature, and particulate and acidic deposition patterns. Consider controlled emissions, fugitive air emissions and odours."

Response

Existing air quality can be defined through ambient monitoring and the application of dispersion modelling. The former is limited to observations collected to date and the benefits of future changes are not accounted for. The modelling can evaluate the benefits associated with future reduction in emissions.

Ambient air quality monitoring data are discussed in Report 2 (Ambient Air Quality Observations in the Athabasca Oil Sands Region) and are also summarized in Section A of this report. The following discussions provides a further summary:

- High **SO_2 concentrations** (i.e., in excess of both the 450 and 900 $\mu g/m^3$ guidelines) have been observed on the edge of the Athabasca River valley escarpment (e.g., at the Fina and Mannix air monitoring stations). Dispersion modelling confirms these high occurrences and identifies the Suncor Powerhouse as the major contributor. A review of concurrent meteorological conditions indicate that observable SO_2 concentrations are associated with either one of the two oil sands being upwind of the monitoring stations and these values are associated with daytime convective and/or limited trapping conditions.

- Relatively high (i.e., in excess of 14 $\mu g/m^3$) **H_2S concentrations** have been observed at all locations, but most frequently at the Mannix, Lower Camp and AQS3 (Mildred Lake) air monitoring stations. A review of the meteorological conditions indicate these events are likely caused by low-level sources and they occur during stable nighttime periods.

- Median **THC concentrations** are typically in the 1.4 to 2.1 ppm range. Maximum values in excess of 30 ppm, however, have been observed at Poplar Creek and Athabasca Bridge. Chanelling of fugitive THC emissions from Suncor is the likely cause of the high values at Fort McMurray and Fort MacKay. The maximum values at these locations are less than those observed at either Poplar Creek and Athabasca Bridge are less (8.6 and 4.1 ppm, respectively).

- The highest **NO_2 concentration** was observed in Fort McMurray. The maximum value of 440 $\mu g/m^3$ exceeded the guideline value of 400 $\mu g/m^3$. The relatively large NO_x values in Fort McMurray are the result of local traffic and residential wood combustion.

- **VOC's**, that is non-methane hydrocarbons, are not monitored on a routine basis. Selected intermittent measurements of VOC's have been conducted. The larger concentrations, not unsurprisingly, occur near the Suncor and Syncrude plant areas. As VOC monitoring is not routine, it is difficult to establish trends.

- **Ozone** is only monitored at Fort McMurray and relatively high values are observed during the late afternoon hours in late spring and the summer months. In 1990, there were 16 recorded exceedences of the hourly guideline of 80 ppb; since then (to mid 1995) there have only been 4 exceedences. On average, there are 135 exceedences per year of the daily guideline. This is typical of rural Alberta areas and has been attributed to natural sources.

Air quality modelling predictions are presented in Report 4 (Ambient Air Quality Predictions in the Athabasca Oil Sands Region) and in Section A of this report:

- The SO_2 model predictions support the observations at the air monitoring trailers. In addition, the modelling indicates hourly concentrations in excess of 900 $\mu g/m^3$ and maximum daily concentrations in excess of 150 $\mu g/m^3$ could occur on the elevated terrain towards Muskeg Mountain and Thickwood Hills.

- Relatively large (greater than 1000 $\mu g/m^3$) SO_2 concentrations due to abnormal flaring are predicted to occur within a few kilometres of both the Suncor and Syncrude flare stacks (Report 4: Ambient Air Quality Predictions in the Athabasca Oil Sands Region).

- The maximum sulphur deposition of 25.5 kg SO_4 equivalent/ha/a is predicted to occur 26 km to the north-northwest of the Powerhouse stack. High values are also predicted to occur 20 km to the south-southwest of the Powerhouse stack.

- Model predictions indicate maximum NO_x concentrations tend to occur within 1 km of the respective plant sites. Off-site NO_2 concentrations are likely well below guideline values.

- Ambient CO concentrations are well within guideline values.

- Maximum deposition of particulates from the Powerhouse stack occur on the plant site and decrease rapidly with increasing distance from the plant (Report 4: Ambient Air Quality Predictions in the Athabasca Oil Sands Region).

Ambient air quality modelling was undertaken for ozone by Concord Environmental (1993). The results indicated a high background ozone concentration. The effect of NO_x and VOC emissions was to produce a slight increase in the ozone levels in Fort McMurray. Alberta Environment states that the "majority of O_3 in the Fort McMurray region is likely generated by natural background sources (Angle and Sandhu 1986) although, a portion of the O_3 may result from emissions of oxides of nitrogen and hydrocarbons for motor vehicles or industrial sources" (Myrick 1992).

Impact Classification

None required.

D2.8 AMBIENT AIR QUALITY CHANGES

"Characterize the existing air quality and identify air quality parameters of concern. Review current emission sources and anticipated future development scenarios within the Study Area. Discuss appropriate air quality parameters such as SO_2, H_2S, total hydrocarbons NO_x, VOC's, ground-level ozone, as well as, wind direction, wind speed, temperature, and particulate and acidic deposition patterns. Consider controlled emissions, fugitive air emissions and odours."

"Model regional air quality including consideration of terrain features. Justify the use of selected dispersion model(s) and identify any short-comings of the models or constraints to their findings. Address both local and regional effects and assess their implications."

Dispersion model predictions were used to determine air quality changes associated with changes in emissions associated with the Fixed Plant Expansion and the Steepbank Mine. Other regional sources are included in the assessment for the evaluation of SO_2 emissions.

D2.8.1 SO_2 Concentrations

Normal Emissions

Ambient SO_2 concentrations are expected to decrease as a result of the SO_2 reduction program. From a regional perspective:

- The maximum one-hour average SO_2 values are expected to decrease from the 1279 to 1652 $\mu g/m^3$ (0.48 to 0.62 ppm) range to the 437 to 454 $\mu g/m^3$ (~ 0.17 ppm) range. The maximum number of hourly exceedences (values in excess of 450 $\mu g/m^3$) is expected to decrease from about 37 to 49 per year to about one per year.

- Maximum daily average SO_2 values are expected to decrease from the 246 to 311 $\mu g/m^3$ (0.09 to 0.12 ppm) range to the 125 to 129 $\mu g/m^3$ (~ 0.05 ppm) range. The number of predicted daily exceedences (daily values in excess of 150 $\mu g/m^3$) is expected to decrease from 3 days per year to none.

- Maximum annual average SO_2 values are expected to decrease from the 12 to 16 $\mu g/m^3$ (~ 0.005 ppm) range to about 8 $\mu g/m^3$. This compares to the background value that ranges between 1 and 4 $\mu g/m^3$.

Abnormal Emissions

Notwithstanding the positive benefits of SO_2 reduction programs, there are still two issues of concern with respect to SO_2 emissions. These include:

- **Planned and unplanned intermittent flaring.** The evaluation undertaken in Report 4 (Ambient Air Quality Predictions in the Athabasca Oil Sand Region) indicated relatively high SO_2 concentrations could occur with intermittent flaring. While the evaluation was undertaken on a collective basis, a further evaluation of individual case events may be warranted to provide a better definition of the type of concentrations that actually occurred.

  This assessment for the proposed integrated operation has not assumed any reductions in either the SO_2 emissions or the frequency of intermittent flaring. It is understood, however, that Suncor is reviewing ways to minimize this type of flaring.

- **FGD downtime.** During planned or unplanned downtime of the FGD system, the emissions and associated maximum concentrations will be similar to the 1994/95 levels.

D2.8.2 Deposition

Deposition refers to the removal of emissions from the atmosphere by aquatic and terrestrial ecosystems through wet and dry deposition processes. The wet removal involves the action of precipitation through rainout and washout mechanisms. Wet removal of SO_2 results in the direct delivery of weak acids to the receptor. Dry deposition involves the uptake of SO_2 and sulphates by the receptor. Biochemical reactions on and within the receptor result in the formation of acids. The sensitivity of the environment to acidification is dependent on the buffering capacity of the soils and waters.

Deposition can be expressed in terms of sulphur compound equivalent deposition (e.g., kg SO_4^{-2} equivalent/ha/a) or as an effective acidity (kmol H^+/ha/a). The latter accounts for the presence of other acidifying or neutralizing compounds in the precipitation or the receptor.

Although Alberta Environmental Protection has issued preliminary deposition loading limits, there is a lack of consensus by the technical and regulatory communities on how to calculate EA and what criteria should be used to judge the values by. Although wet, dry and total deposition, as well as EA have been calculated as part of this assessment, it is recommended that the predictions only be used on a relative basis. It is on this understanding that the effects associated with acidification are addressed.

Table D2.0-7 compares the maximum deposition associated with Suncor and all regional sources for the current (1995) and proposed (1998 and 2001) emission scenarios. The effect of the FGD system (1998 and 2001) is to reduce the total deposition by a factor of three. Due to the presence of these other sources, the reduction of the maximum deposition associated with the 1998 and 2001 emission scenarios is by about 44%. The reduction of effective acidity (EA) is about 35%.

The EA estimation conservatively assumes all the deposited sulphur compounds will be converted to an acid and that the background value is 0.13 kmol H^+ equivalent/ha/a. This background value is comprised of 0.05 kmol H^+ equivalent/ha/a as wet deposition and 0.08 kmol H^+ equivalent/ha/a as dry deposition. These values are based on Cree Lake observations (Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region).

TABLE D2.0-7
MAXIMUM PREDICTED DEPOSITION ASSOCIATED WITH CURRENT AND PROPOSED SO_2 EMISSIONS

YEAR	SUNCOR UTILITIES[a]			ALL REGIONAL SOURCES[b]	
	DEPOSITION (SO_4^{-2} equivalent/ha/a)			TOTAL DEPOSITION (SO_4^{-2} equivalent/ha/a)	EFFECTIVE ACIDITY (kmol H^+/ha/a)
	DRY	WET	TOTAL		
1995	13.6	8.2	19.2	25.5	0.66
1998	3.5	2.1	5.2	13.5	0.41
2001	3.8	2.4	5.8	14.4	0.43

(a) 1995: Powerhouse stack
1998 and 2001: FGD stack

(b) 1995: three sources
1998 and 2001: five sources

D2.8.3 NO_x Concentrations

NO_x emissions associated with the operation of the Suncor Fixed Plant Expansion and the Steepbank Mine are not expected to change significantly from those associated with the existing facilities. As modelling predictions and ambient observations did not indicate that NO_2 concentrations were likely to exceed guidelines, the modelling was not undertaken for either the proposed 1998 or 2001 emission scenario.

D2.8.4 CO Concentrations

CO concentrations that have been observed in the area are less than the associated guideline value. This observation is supported by the dispersion model predictions. As such, revised ambient CO concentration predictions were not undertaken.

D2.8.5 PM_c Concentrations

PM_c emissions associated with the operation of the Powerhouse are well within ambient guidelines for TSP. With the implementation of the FGD system, the PM_c emissions and associated concentrations are expected to experience an 85% reduction when compared with the current Powerhouse stack.

D2.8.6 THC Concentrations

The high THC concentrations observed in Fort McMurray and Fort MacKay are likely due to fugitive Suncor sources. Total hydrocarbon emissions associated with Suncor operation will decrease from historical values due to the installation of Vapour Recovery Unit (VRU). This coupled with improved operating practices should reduce both the magnitude and frequency of abnormal THC emissions. On the average, the THC values in Fort McMurray and Fort MacKay should be reduced by a factor of two due to the operation of the VRU and hydrotransport.

D2.8.7 TRS Concentrations

The operational improvements associated with reducing THC emissions has the same directional effect on TRS emissions. Ambient TRS concentrations are not estimated for either the current or proposed emission scenarios.

D2.8.8 O_3 Concentrations

Ambient ozone can originate from natural sources (e.g., entrainment of stratospheric ozone into the troposphere) or can be as a secondary product from reaction of NO_x with THC. While NO_x

results primarily from combustion processes, THC emissions can result from both oil sands facilities and natural sources.

In 1990 and 1992, ambient O_3 concentrations exceeded the hourly guideline for 16 and 4 hours, respectively. There were no hourly exceedences in 1991, 1993 or 1994. On average the O_3 concentrations exceed the daily guidelines about 135 days per year. AEP has indicated this is primarily due to natural sources with a likely smaller contribution due to industrial emissions.

The effect of increased NO_x emissions was evaluated for Syncrude (Concord Environmental 1993). An increase in the NO_x emissions by 65% was found to have a negligible effect on the ozone concentration predictions for the region.

D2.8.9 Impact Summary

Table D2.0-8 provides an overall summary table for expected concentration changes associated with the changes in the emissions. In the application of the ratings, the following are noted:

- Any decreases were viewed as positive regardless of the pre-expansion and new mine conditions.

- SO_2 was rated as moderate since short-term peaks that can exceed guidelines may still occur under abnormal conditions.

- Deposition of sulphur emissions was rated as unknown pending technical and regulatory community selection of a method for estimating EA and finalizing deposition guidelines.

- THC was rated as unknown because of odour potential and because a rigourous evaluation was not undertaken on a compound-by-compound basis.

TABLE D2.0-8

AMBIENT AIR QUALITY IMPACTS ASSOCIATED WITH THE SUNCOR FIXED PLANT EXPANSION AND THE STEEPBANK MINE

	SO_2	DEPOSITION	NO_x	CO	PM_c	THC/VOC	TRS	O_3
Direction	Positive	Positive	Neutral	Neutral	Positive	Positive	Positive	Neutral
Severity	Moderate	Unknown	Low	Low	Low	Unknown	Unknown	Low
Duration	Short-term	Long-term	Short-term	Short-term	Short-term Long-term	Short-term	Short-term	Short-term
Geographical Extent	Regional	Regional	Regional	Regional	Regional	Regional	Regional	Regional
Degree of Concern	Moderate	Moderate	Low	Low	Low	Moderate	Low	Low

- TRS was given a lower overall degree of concern than THC as the TRS emissions are much lower than THC emissions.

- O_3 was rated as low even though daily values in the region exceed guidelines on the basis the causes are natural.

- Short-term is related to acute exposure ranging from one-hour to one-day.

- Long-term refers to annual exposures and/or deposition.

The overall degrees of concern for SO_2 emissions, deposition and THC emissions are rated as moderate. The others are rated as low.

D2.9 GREENHOUSE GASES

"Outline the life-cycle of greenhouse gas emissions for on-site sources and the off-site supply of natural gas electricity.

"Comment on the impact of Suncor's emissions on provincial and federal commitments regarding greenhouse gases."

Identification of greenhouse gas emissions that include CO_2 and CH_4."

Response

CO_2 emissions result primarily from combustion sources. On the Suncor site the combustion fuels include diesel (mine fleet), coke (Powerhouse), natural gas and refinery gas (secondary sources). CH_4 emissions result primarily from fugitive sources. The largest source of CH_4 emissions appear to be from the surface of Tailings Pond #1. Typically, 37% of the hydrocarbon emissions were estimated to be in the form of methane. Current CO_2 and CH_4 emission rates are estimated to be 9643 and less than 2 t/d, respectively. This estimate does not include fugitive methane losses from the upgrading area. The results, however, indicate CO_2 emissions are much larger than those associated with CH_4 (by a factor of ~ 5000).

The operation of the Suncor facilities can be based on CO_2 emissions representing all greenhouse gases. From an efficiency perspective, CO_2 emissions are expected to decrease from 124 t CO_2/1000 barrels of hydrocarbon product (1995) to 98 t CO_2/1000 barrels of product (2001). From an absolute perspective CO_2 emissions are expected to increase from 1990 levels of 9312 t/d to 9819 t/d in 2001 (5% increase). This difference is within the error of estimation.

Impact Classification

Table D2.0-9 provides the application of the impact classification approach to greenhouse gas emissions. The results are discussed in absolute terms as well as in efficiency terms. The duration and geographic extent are defined as long-term and global, respectively to account for potential climate changes. The overall rating is defined as low since the gross production between 1990 and 2001 is expected to increase by 82%, with a CO_2 increase of 5%.

TABLE D2.0-9

IMPACT ANALYSIS FOR GREENHOUSE GAS EMISSIONS

	ABSOLUTE	EFFICIENCY
Direction	Negative	Positive
Magnitude	5% Increase	21% Reduction
Duration	Long-term	Long-term
Geographical Extent	Global	Global

Recommendations

The estimation of CO_2 emissions through the use of emission factors can result in some uncertainty. For example, Suncor estimates the uncertainty of their CO_2 emission estimates to be in the ± 10 to 20% range. This compares to the projected increase from 1990 to 2001 of 5%. It is recommended that the goals be commensurate with the measurement process. Suncor has indicated a need to ensure greater accuracy in obtaining greenhouse gas emission estimates.

Mitigation

The Canadian government has committed Canada to reduce greenhouse gas emissions to 1990 levels by the year 2000. The 1990 values were selected as a basis for comparison to encourage countries to commit to limiting and reversing CO_2 emission trends. Suncor has committed to identify opportunities for further reduction in the future.

E MONITORING

Monitoring forms an integral part of an air quality management plan that ensures the operation of an industrial facility is consistent with agreeable ambient air quality. Monitoring is typically comprised of activities to characterize the magnitude and nature of releases to the atmosphere (source monitoring) and activities to characterize ambient exposures (ambient monitoring). This can be supplemented by meteorological monitoring to obtain an understanding of the source to exposure pathway and by receptor monitoring to obtain an understanding of exposure to response pathway. Ultimately the interest is on the effects air emissions have on receptors such as humans, vegetation, soils and water bodies. The following comments are made with a view to help validate impact predictions and to monitor the success of source control activities.

E1.0 SOURCE MONITORING

While source monitoring is undertaken for major emission sources on a continuous basis (e.g., Powerhouse stack, Incinerator stack), the monitoring for the smaller sources (both controlled and fugitive) tend to be undertaken on a more limited basis. The estimation of emissions from emission factors can cause uncertainty as they may be extrapolated beyond their range of application.

The estimation of emissions by industrial facilities is motivated by emission inventory requirements specified by regulators (i.e., AEP annual reports or the federal NPRI (National Pollution Release Inventory) requirements). The inventory results are usually expressed on an annual basis and as such, are of limited use for air quality assessment purposes. This is because the latter requires a measure of temporal variability as well as the characterization and quantification of emissions. It is recommended that emission inventory data be collected with this assessment requirement in consideration.

While some sources are difficult to measure due to either number (e.g., leaks from piping) or type (e.g., pond surfaces), there are methods that can be applied. These methods, however, are often applied on an infrequent basis and generally do not account for temporal changes associated with operations (e.g., upsets, changes in season). It is recommended that consideration be given to more frequent (e.g., quarterly) measurements to supplement the current monitoring.

E2.0 AMBIENT MONITORING

The current ambient air quality monitoring program conducted by Suncor, Syncrude and AEP is under review through the Regional Air Quality Coordinating Committee (RAQCC). Due to the location of the Steepbank Mine, the Fina ambient monitoring site will be decommissioned and any replacement station, if required, will be coordinated through RAQCC. The purpose of the review is to ensure chronic low-level exposure is adequately characterized and to ensure that the right parameters are measured. Some suggestions for the collection of data are as follows:

- Leave the Fina station at its current location for as long as possible to provide a measure of improvement associated with the FGD system.

- Low-level concentration measurements should be divided into night-time and day-time values to allow a more accurate estimation of dry deposition.

- The Fort McMurray precipitation monitoring site should be moved outside the city to an area that would reduce interferences.

- Sampling for particulate matter 10 μm in diameter or less (PM_{10}) should be undertaken in the communities of Fort McMurray and Fort MacKay.

Finally, a digital database of ambient air quality data that has received an appropriate level of quality assurance and control should be established and maintained.

E3.0 RECEPTOR EFFECTS MONITORING

As part of regional initiatives, Suncor will be participating in a regional bioreceptor monitoring program and in a community health effects study.

Suncor is a sponsor and active participant of an environmental effects monitoring program. A number of receptor plots for two dominant ecosystem types will be selected for a multi-year evaluation. This program has been partially implemented through the recent measure of water quality under snow melt conditions. The remaining components are currently under design.

Suncor is also a sponsor and active participant in the Alberta Oil Sands Community Exposure and Health Effects Assessment Program being led by Alberta Health. This program is designed to measure exposures during a 24-hour cycle, which will include residential, environmental and occupational exposures. Three hundred Fort McMurray participants from all levels of income and job types will be enrolled in this study. The study will collect exposure information throughout a 1-year period, which will provide information about seasonal variations and behaviour. Daily records of events during the sample collection period will be made into a personal diary by each participant. A questionnaire will provide background medical histories of participants, as well as demographic information. The program will be continued for a period of years to permit assessment of changes in community health over time.

The samples collected will be analyzed for sulphur dioxide (SO_2), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), and total reduced sulphur compounds (TRS) in an accredited laboratory with validated protocols. The information will be used to establish a baseline for health status for the Fort McMurray community for air quality, as well as determine the relative contribution to exposure of residential, outdoor (environmental), and occupational environments.

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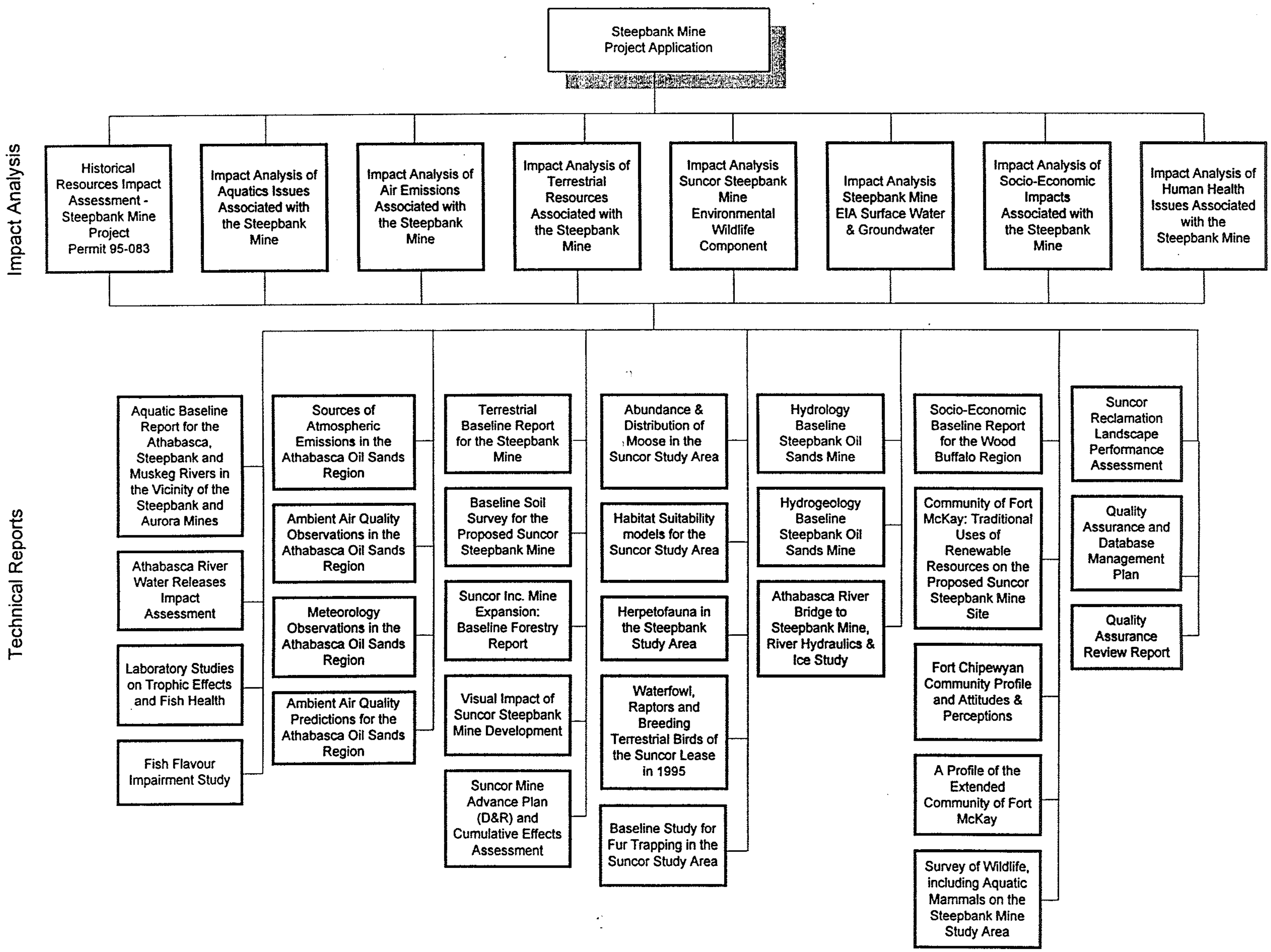
FIGURE A1.0-1

REPORTS PREPARED FOR THE STEEPBANK MINE ENVIRONMENTAL ASSESSMENT



BOVAR Environmental

FIGURE A6.0-1

SUNCOR REGIONAL AND APPROXIMATE LOCAL STUDY AREA

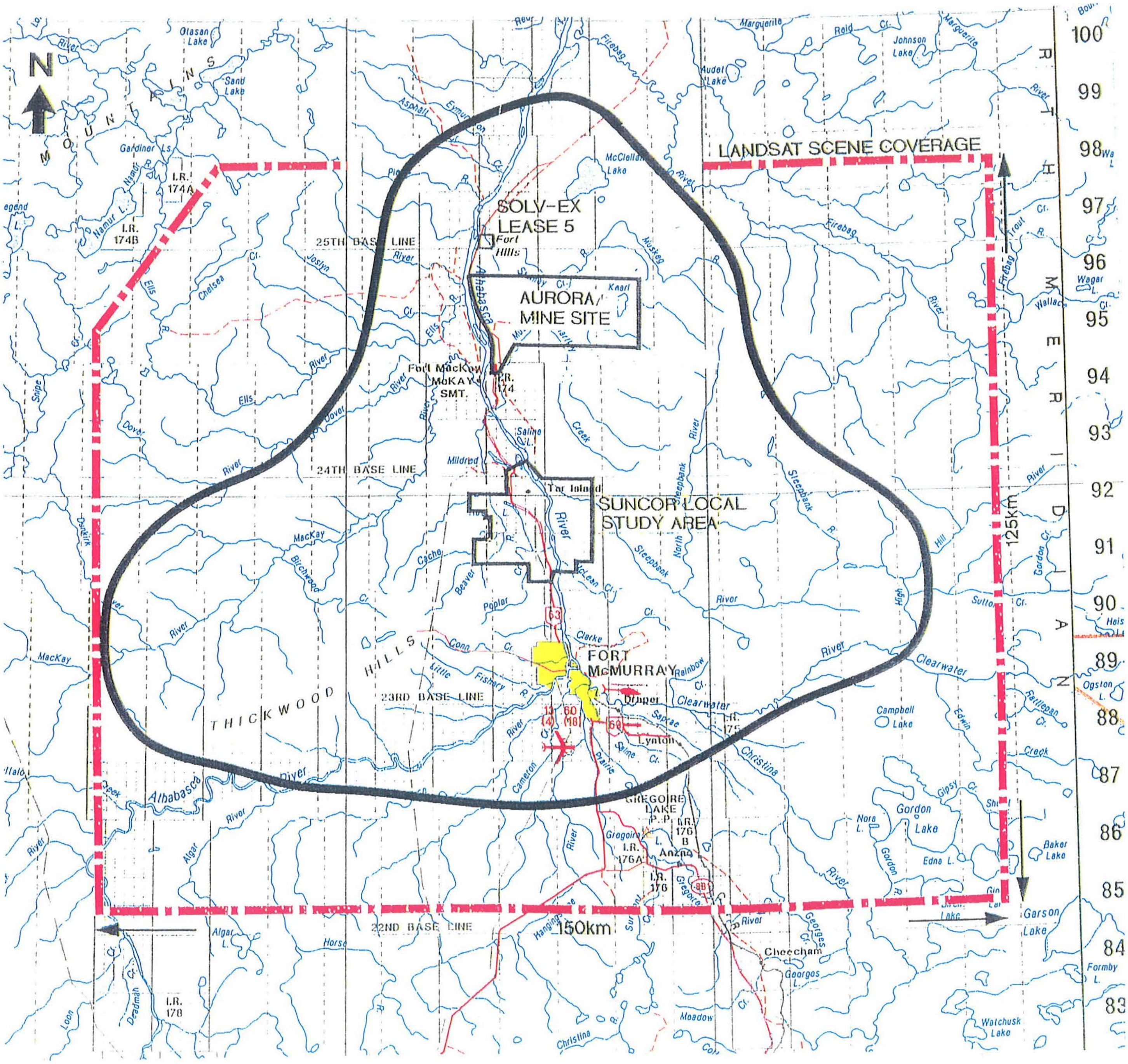


FIGURE B2.0-1

REGIONAL TERRAIN CONTOURS IN THE VICINITY OF THE SUNCOR AND SYNCRUDE PLANTS

(contour interval = 50 m)

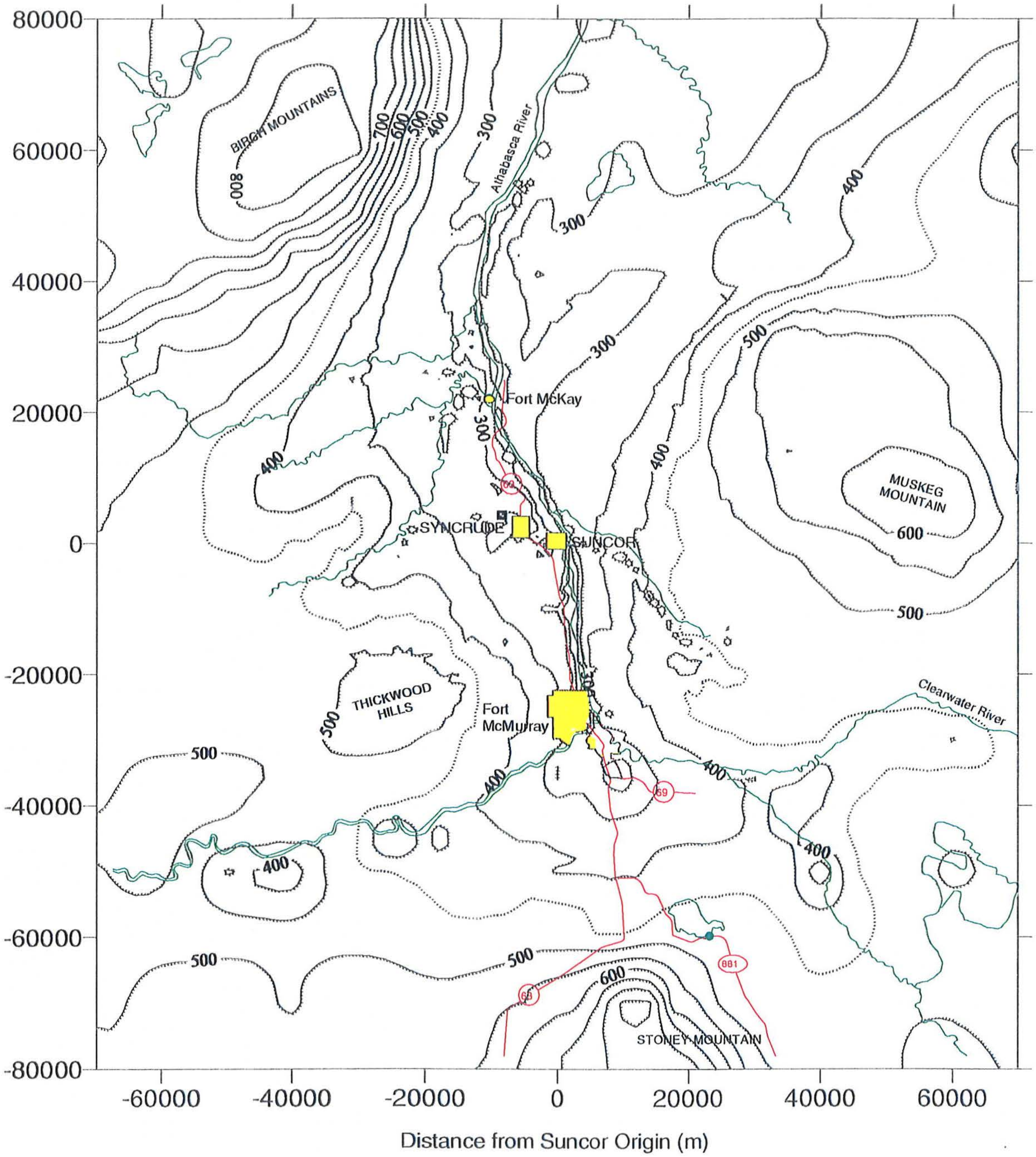


FIGURE B3.0-1

SCHEMATIC OF THE METEOROLOGICAL SENSOR PLACEMENT AT THE LOWER CAMP AND MANNIX MONITORING STATIONS

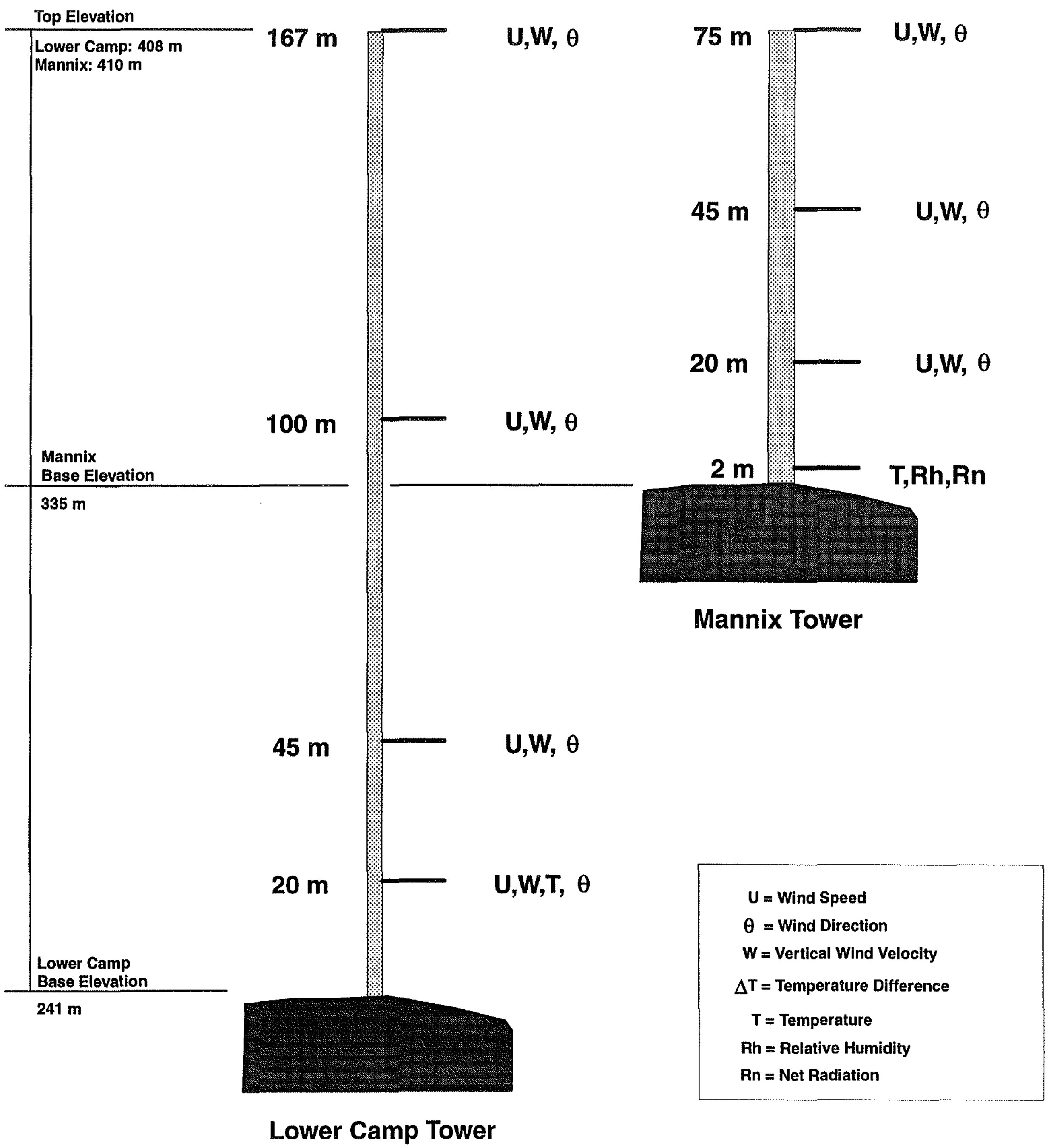


FIGURE B3.0-2

ANNUAL WIND ROSES FOR LOWER CAMP (167 m) AND MANNIX (75 m)

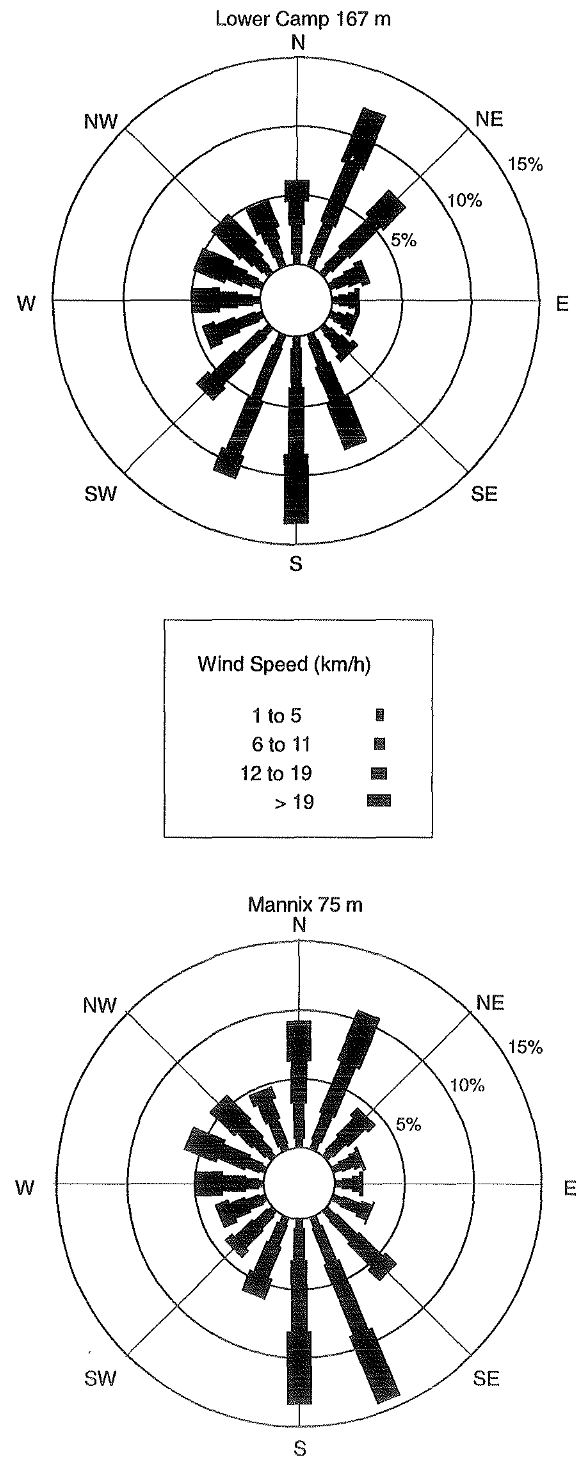


FIGURE B3.0-3

SEASONAL AND ANNUAL WIND SPEED FREQUENCY DISTRIBUTIONS FOR MANNIX

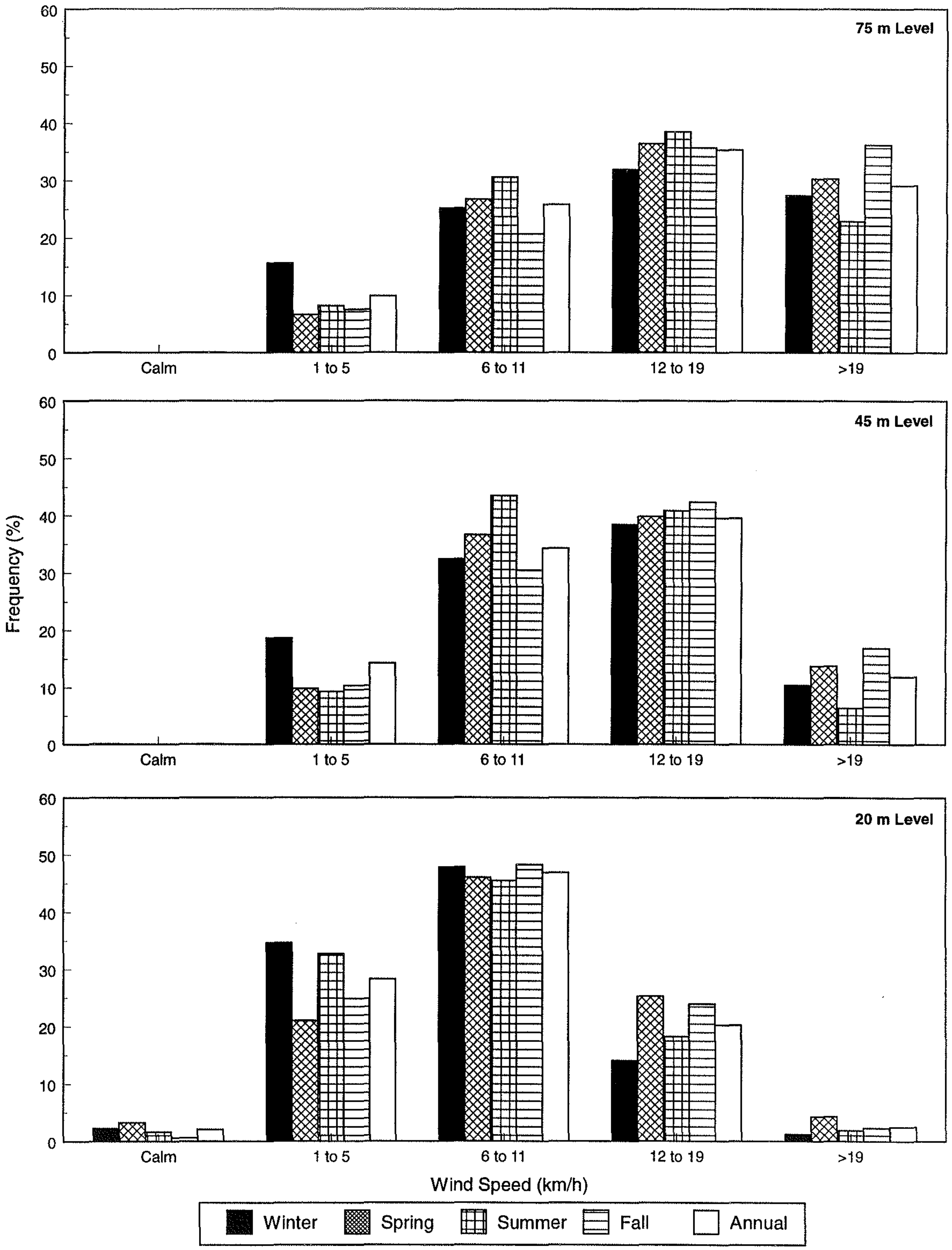
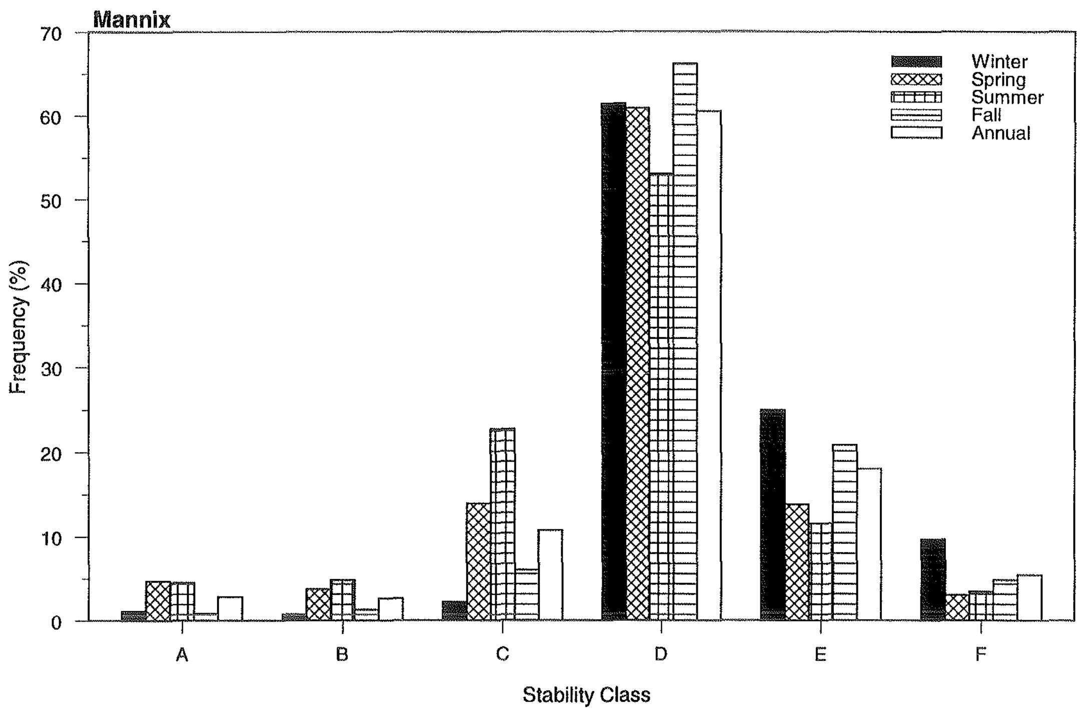


FIGURE B3.0-4

SEASONAL STABILITY CLASS FREQUENCY DISTRIBUTIONS FOR MANNIX (NOVEMBER 1, 1993 TO JUNE 30, 1995) AND FORT McMURRAY AIRPORT (1975 TO 1984) MONITORING STATIONS



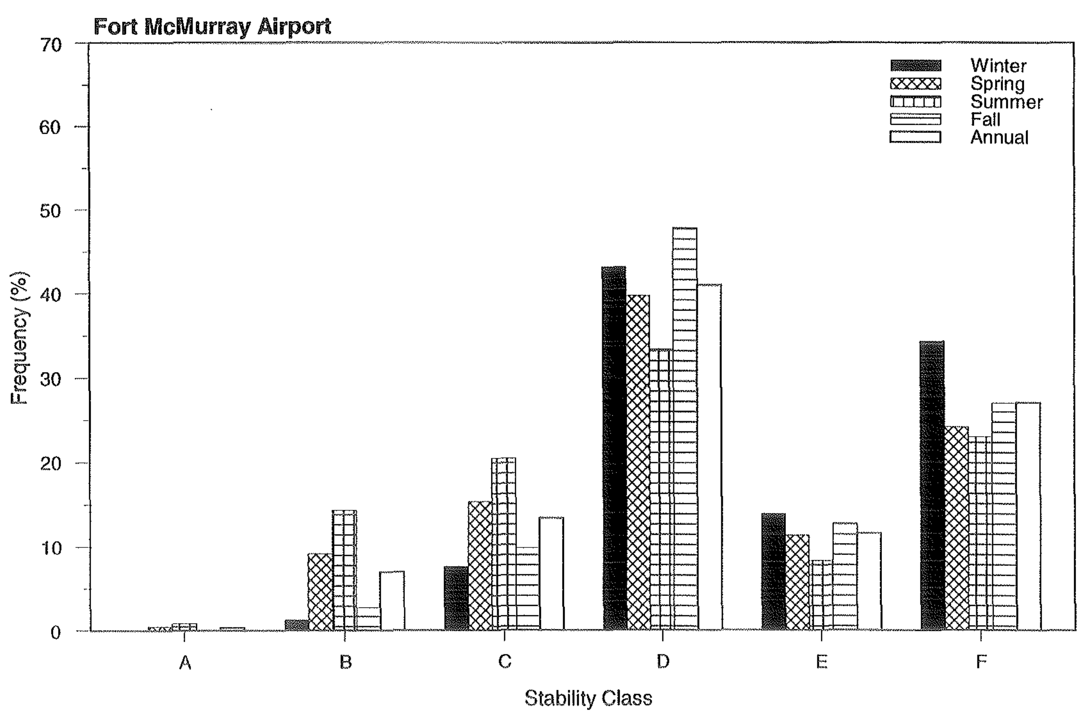
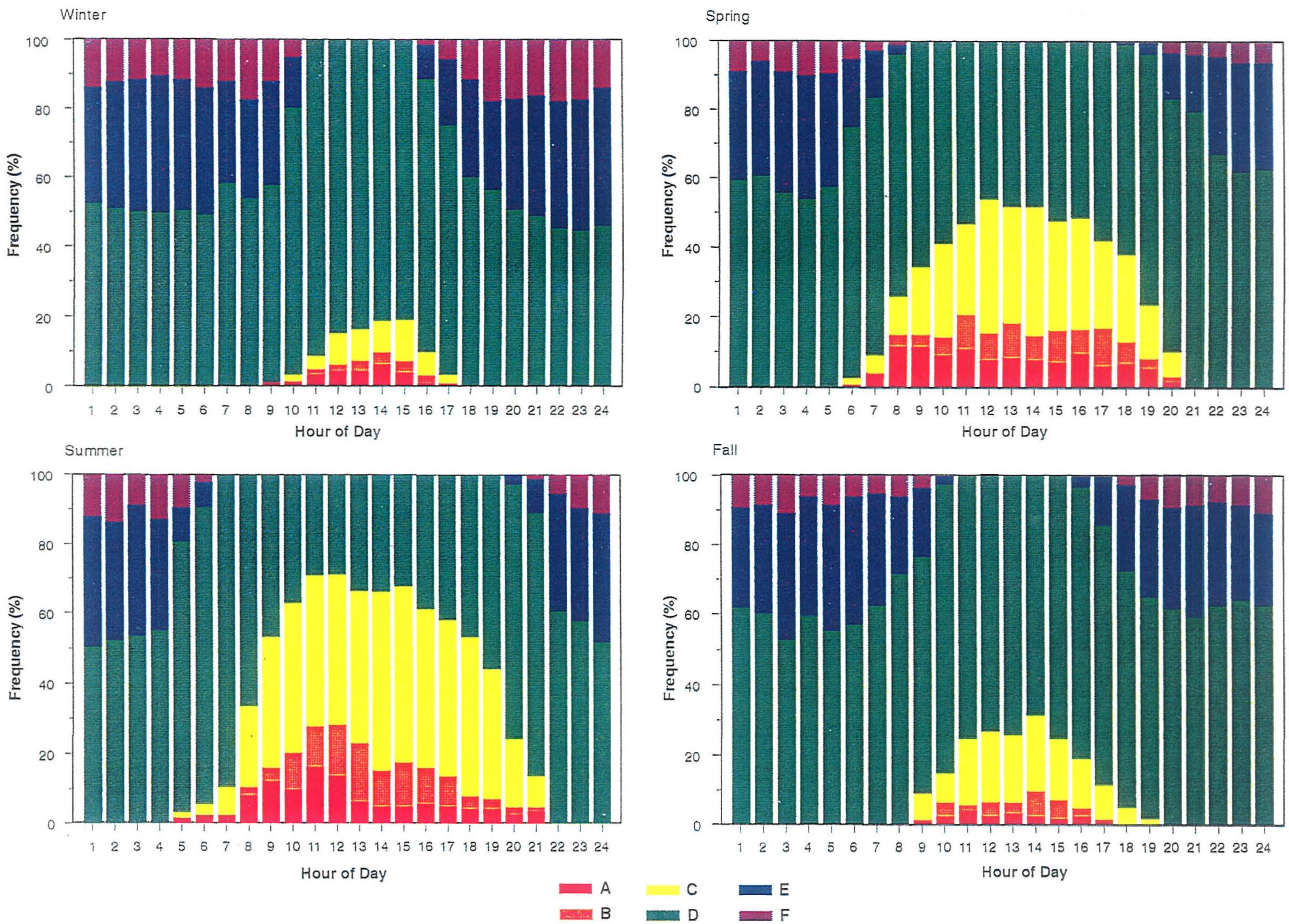


FIGURE B3.0-5

SEASONAL VARIATION OF STABILITY CLASS AS A FUNCTION OF HOUR OF DAY AT THE MANNIX MONITORING STATION



BOVAR Environmental

FIGURE B3.0-6

VARIATION IN SEASONAL MIXING HEIGHTS FOR MANNIX MONITORING STATION WITH RESPECT TO HOUR OF DAY

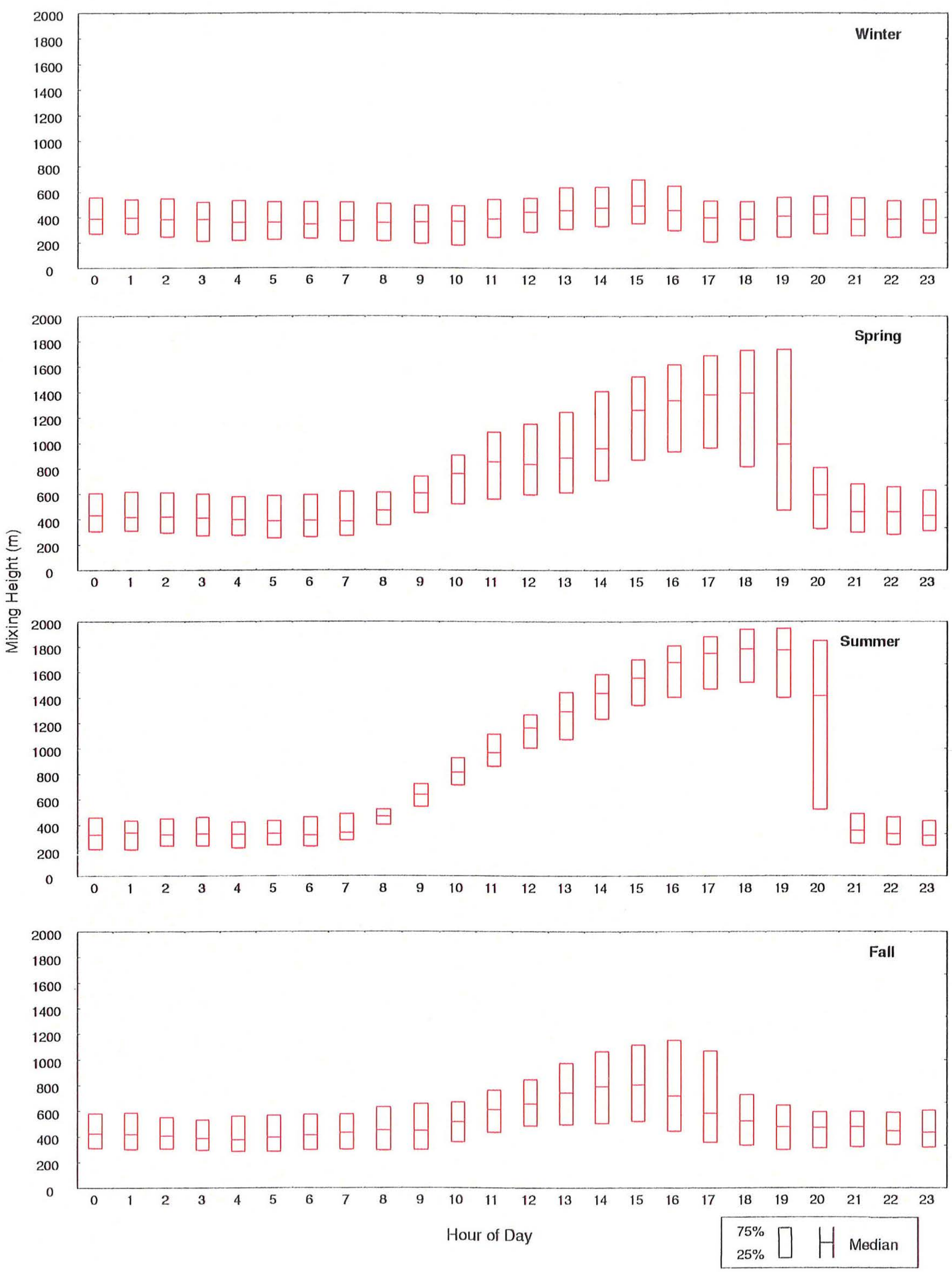


FIGURE B4.0-1

FORT McMURRAY - FORT MacKAY MONITORING NETWORK

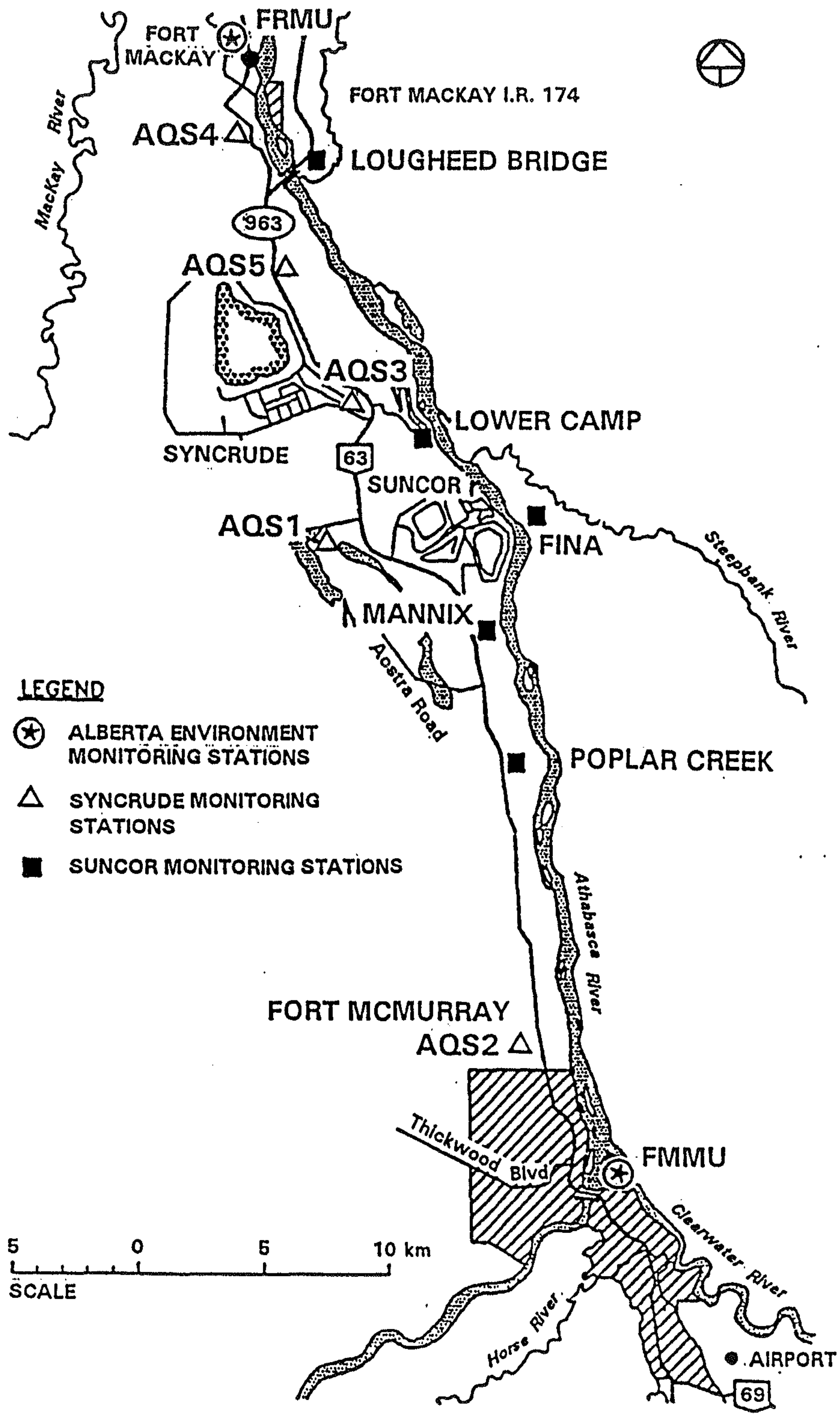


FIGURE B4.0-2

MAXIMUM ANNUAL STATIC EXPOSURE STATION TOTAL SULPHATION VALUES FOR THE PERIOD 1990 TO 1994 (contour values = 0.05, 0.075, 0.1, 0.125, 0.15, 0.2, 0.25, 0.3 0.35, 0.4, 0.5, 0.6, 0.7 mg SO_3^- equivalent/100 cm^2/day)

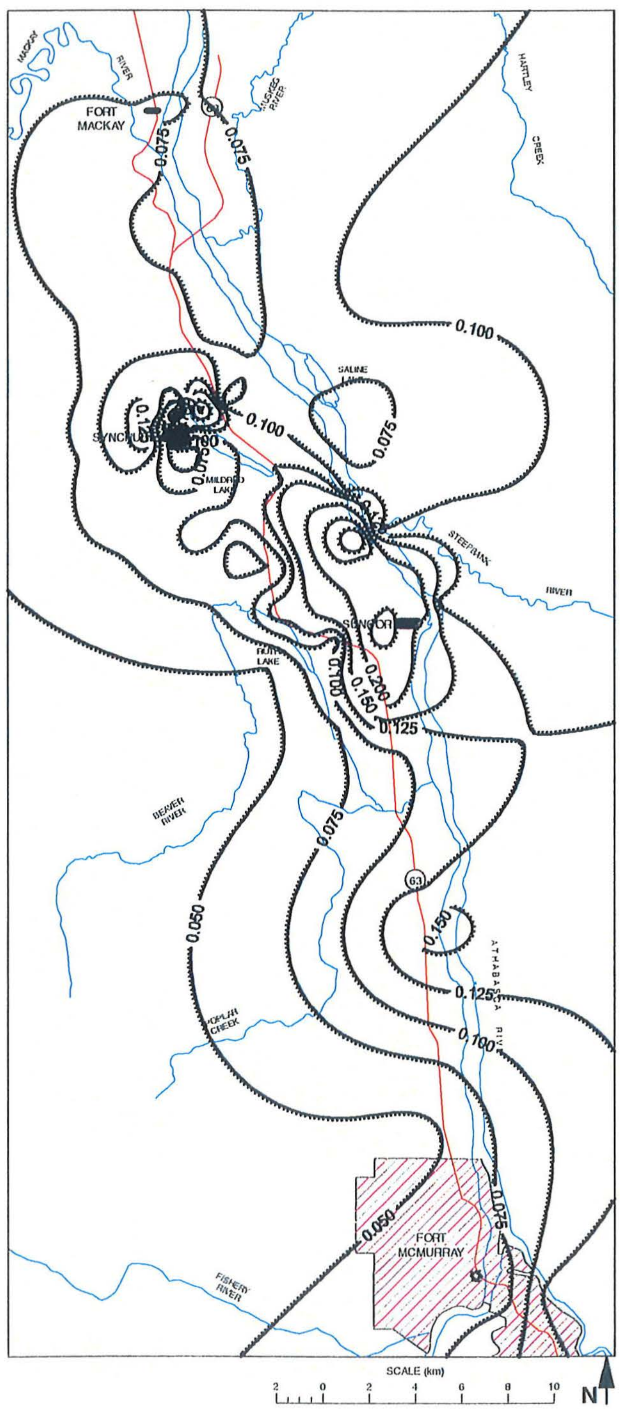


FIGURE B5.0-1

MAXIMUM PREDICTED HOURLY AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE COMBINED OPERATION OF THE SUNCOR AND SYNCRUDE FACILITIES (1995 AVERAGE SO_2 EMISSIONS)

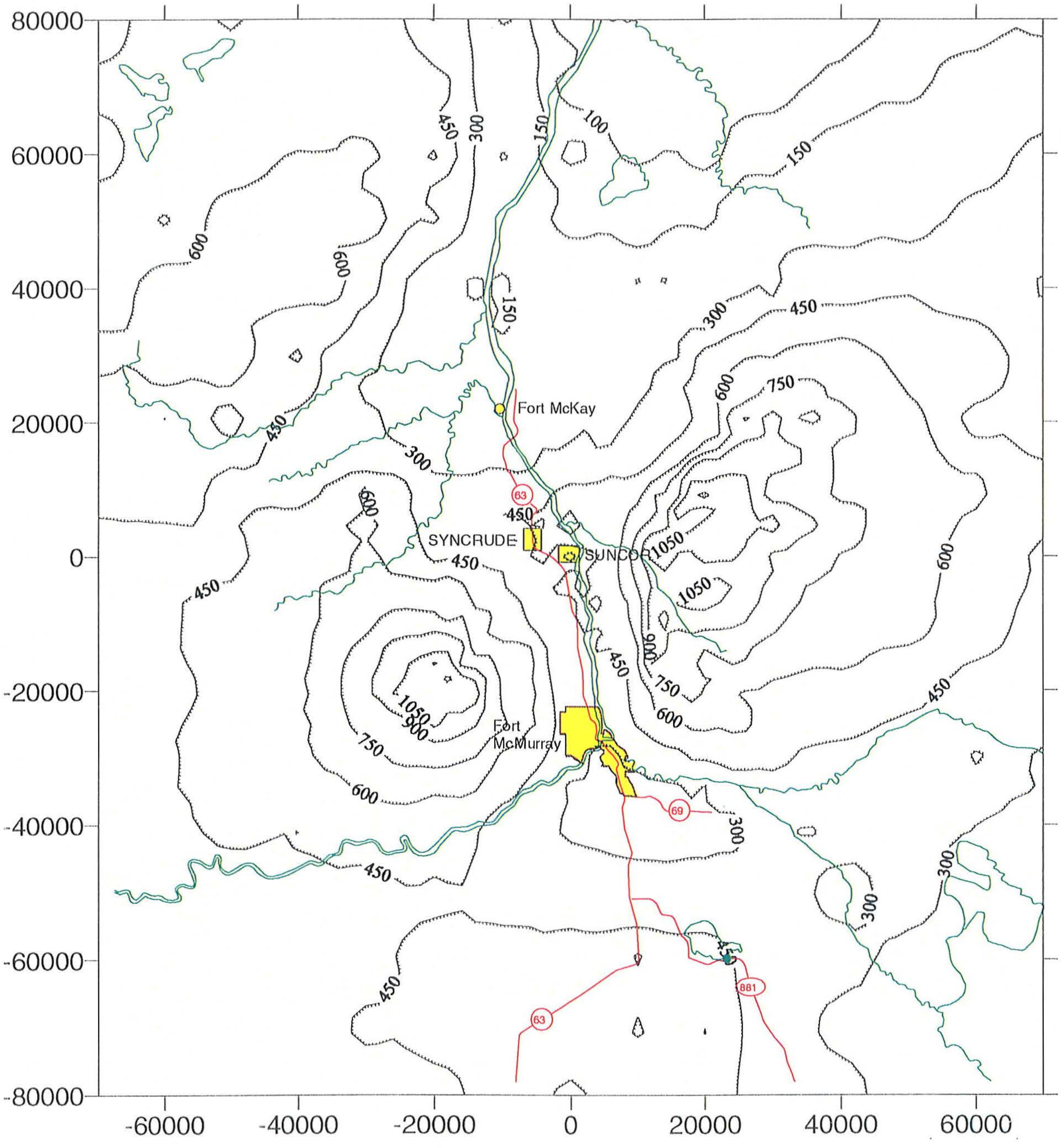


FIGURE B5.0-2

PREDICTED FREQUENCIES OF EXCEEDING THE 450 $\mu g/m^3$ GUIDELINE (h/a) FROM THE COMBINED OPERATION OF THE SUNCOR AND SYNCRUDE FACILITIES (1995 AVERAGE SO_2 EMISSIONS)

VALUES HAVE BEEN NORMALIZED FOR A 12 MONTH PERIOD

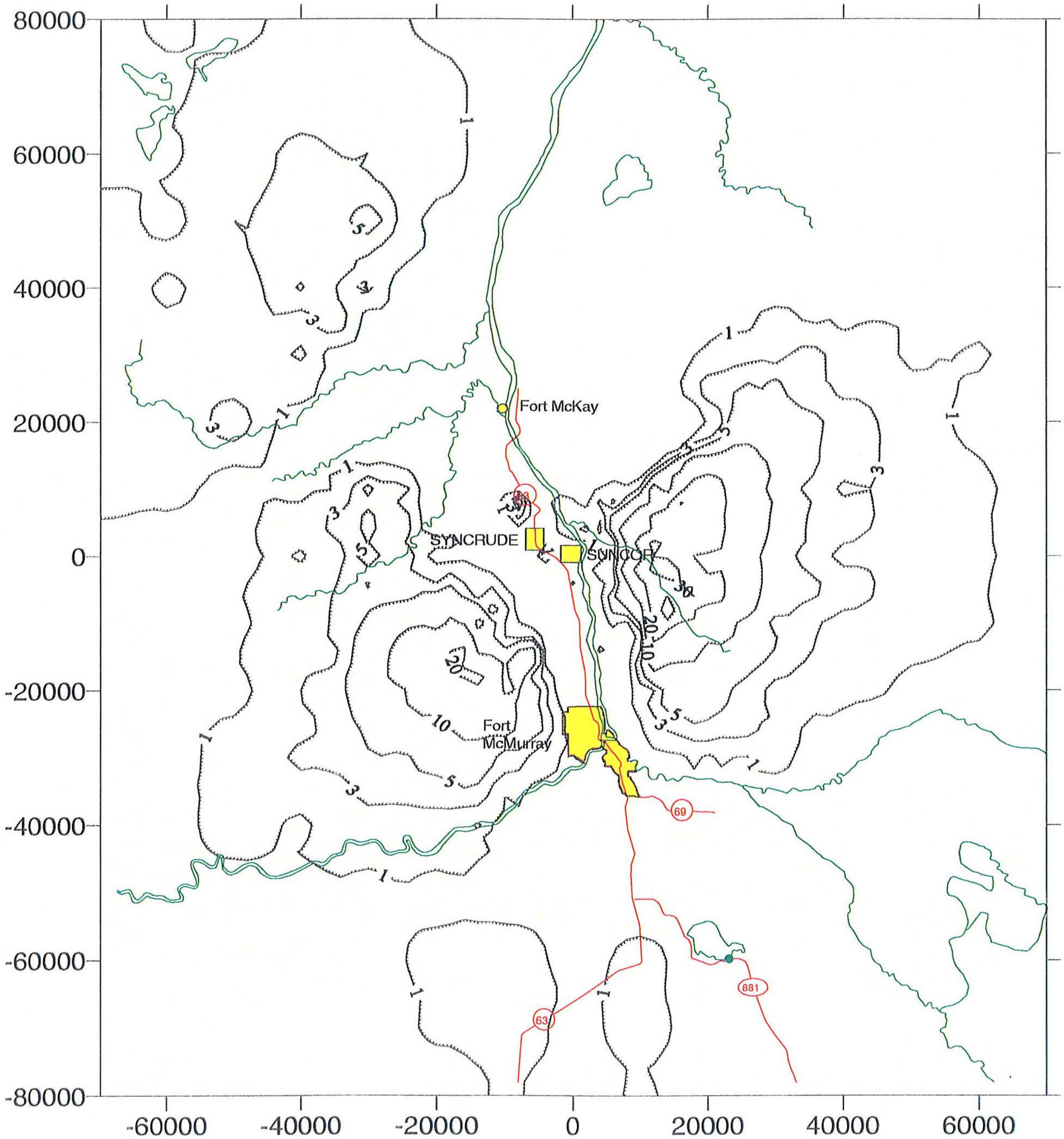


FIGURE B5.0-3

MAXIMUM PREDICTED DAILY AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE COMBINED OPERATION OF THE SUNCOR AND SYNCRUDE FACILITIES (1995 AVERAGE SO_2 EMISSIONS)

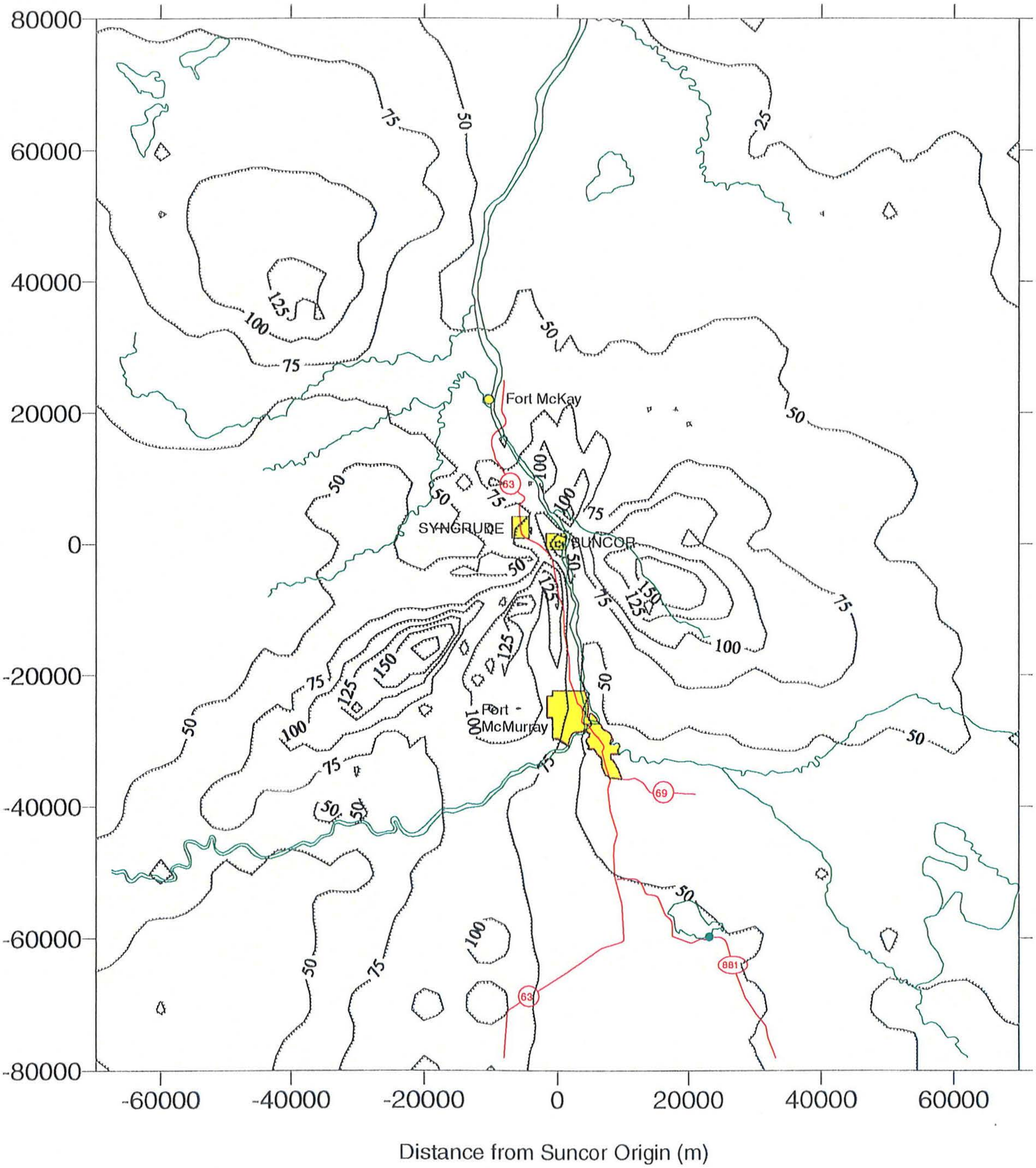


FIGURE B5.0-4

PREDICTED ANNUAL AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE COMBINED OPERATION OF THE SUNCOR AND SYNCRUDE FACILITIES (1995 AVERAGE SO_2 EMISSIONS)

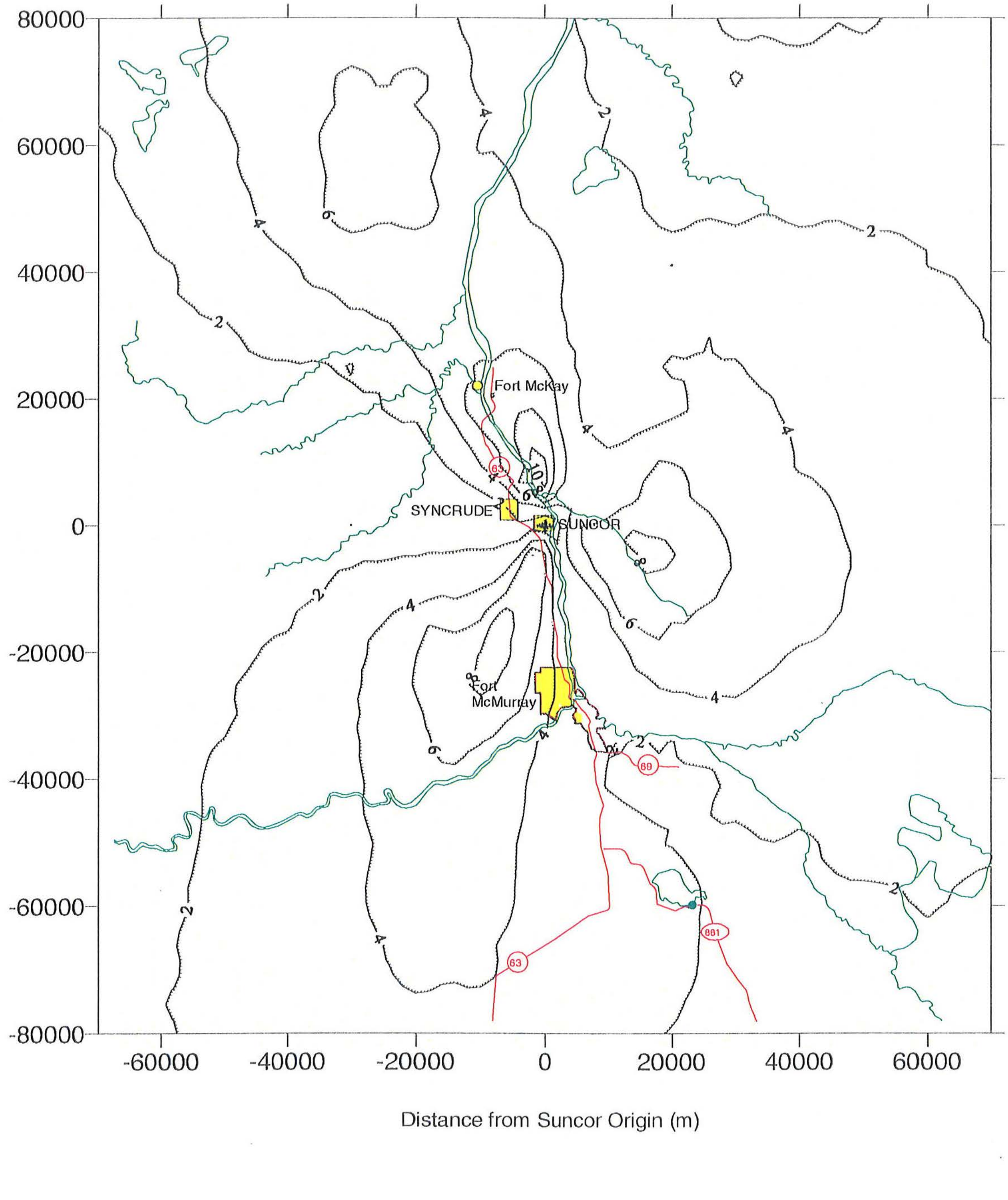


FIGURE B5.0-5

TOTAL (WET + DRY) SULPHATE DEPOSITION (kg SO_4^{-2}/ha/a) FROM THE COMBINED OPERATION OF THE MAIN STACKS IN THE REGION

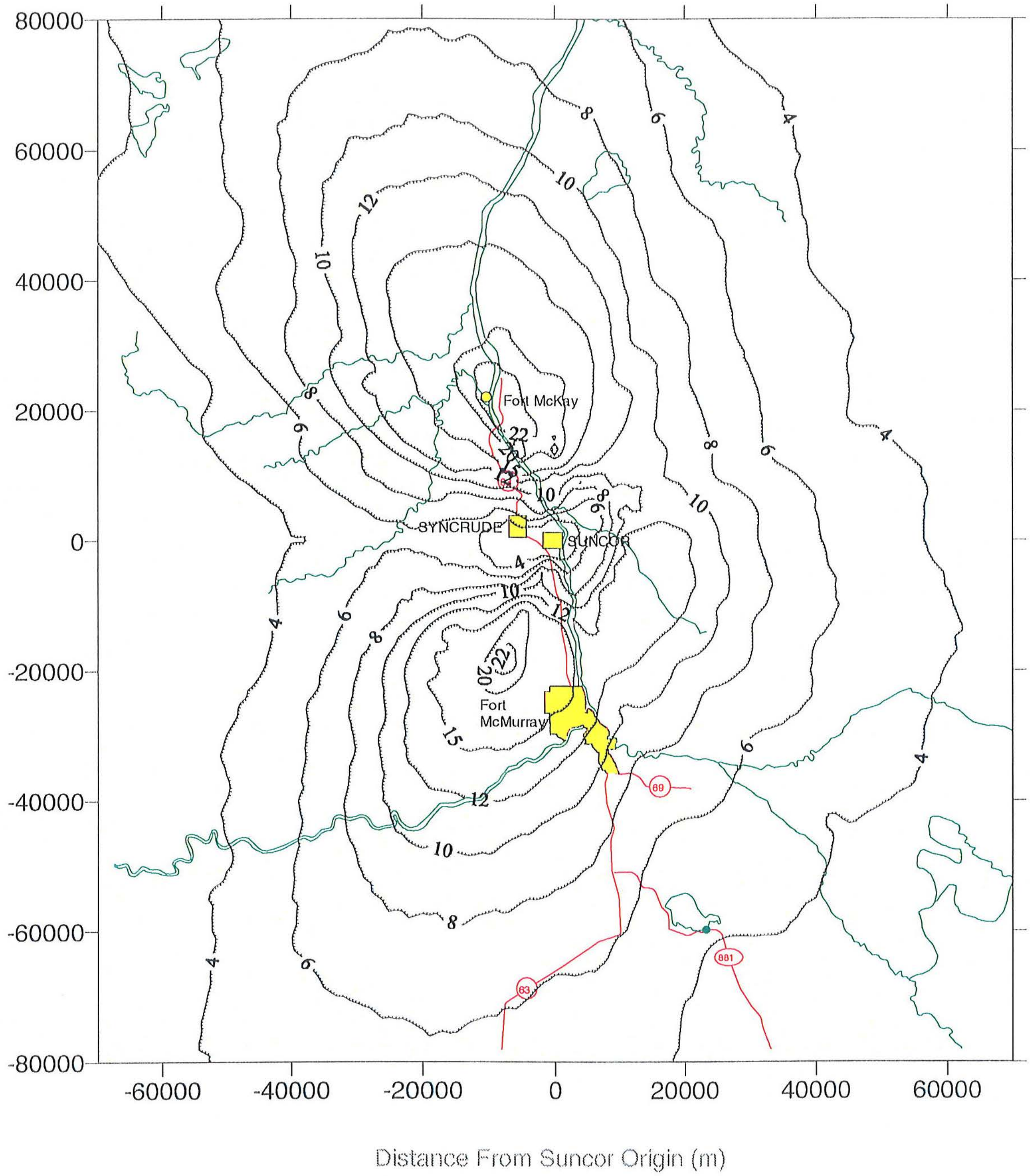


FIGURE B5.0-6

ESTIMATED EFFECTIVE ACIDITY (EA) (kmol H^+/ha/a) FROM THE COMBINED OPERATION OF THE MAIN STACKS IN THE REGION

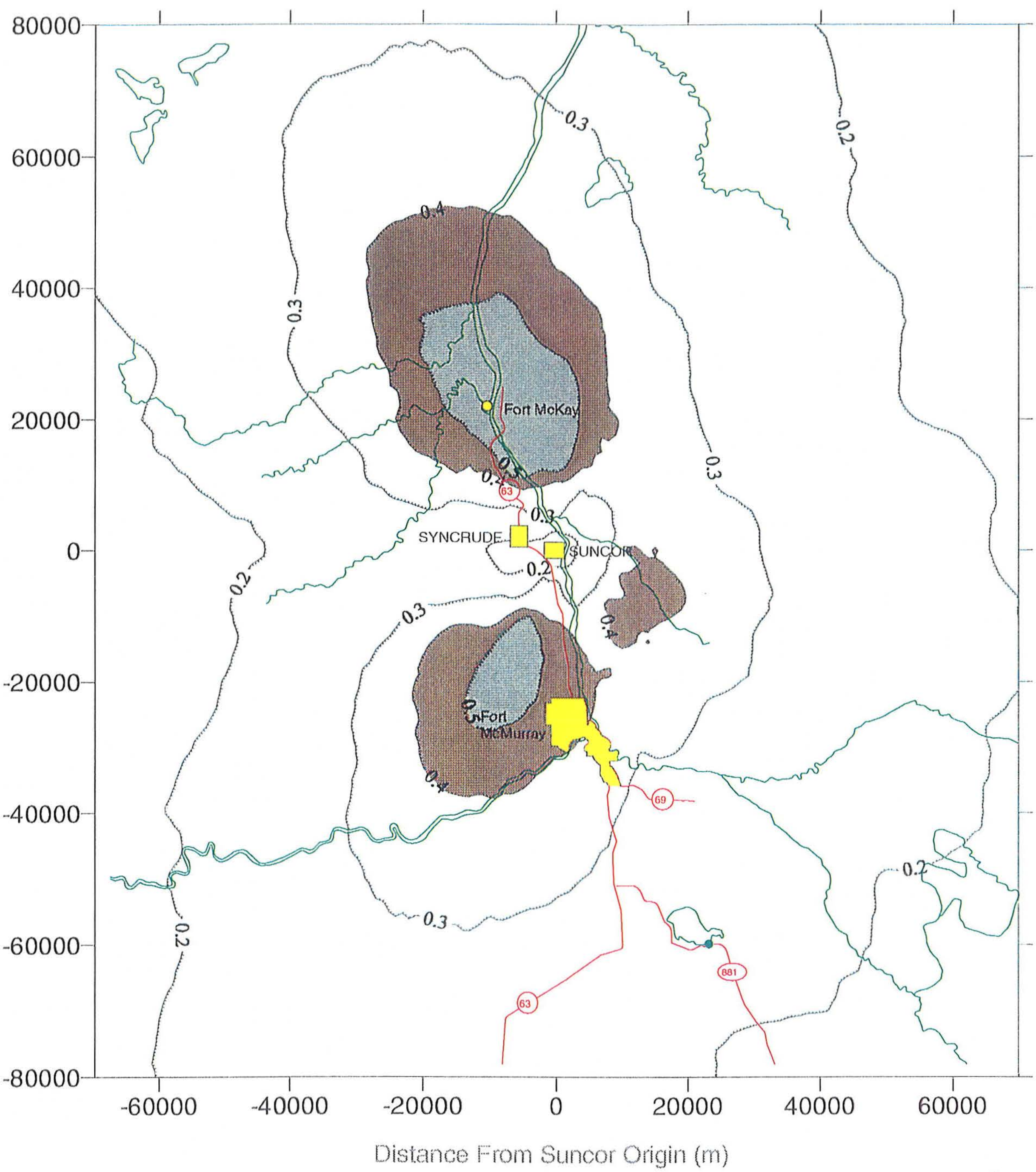


FIGURE C2.0-1

MAXIMUM PREDICTED ONE-HOUR AVERAGE SO_2 CONCENTRATIONS ($\mu g/m^3$) RESULTING FROM THE OPERATION OF THE SUNCOR FGD STACK (SO_2 EMISSIONS = 19.2 t/d)

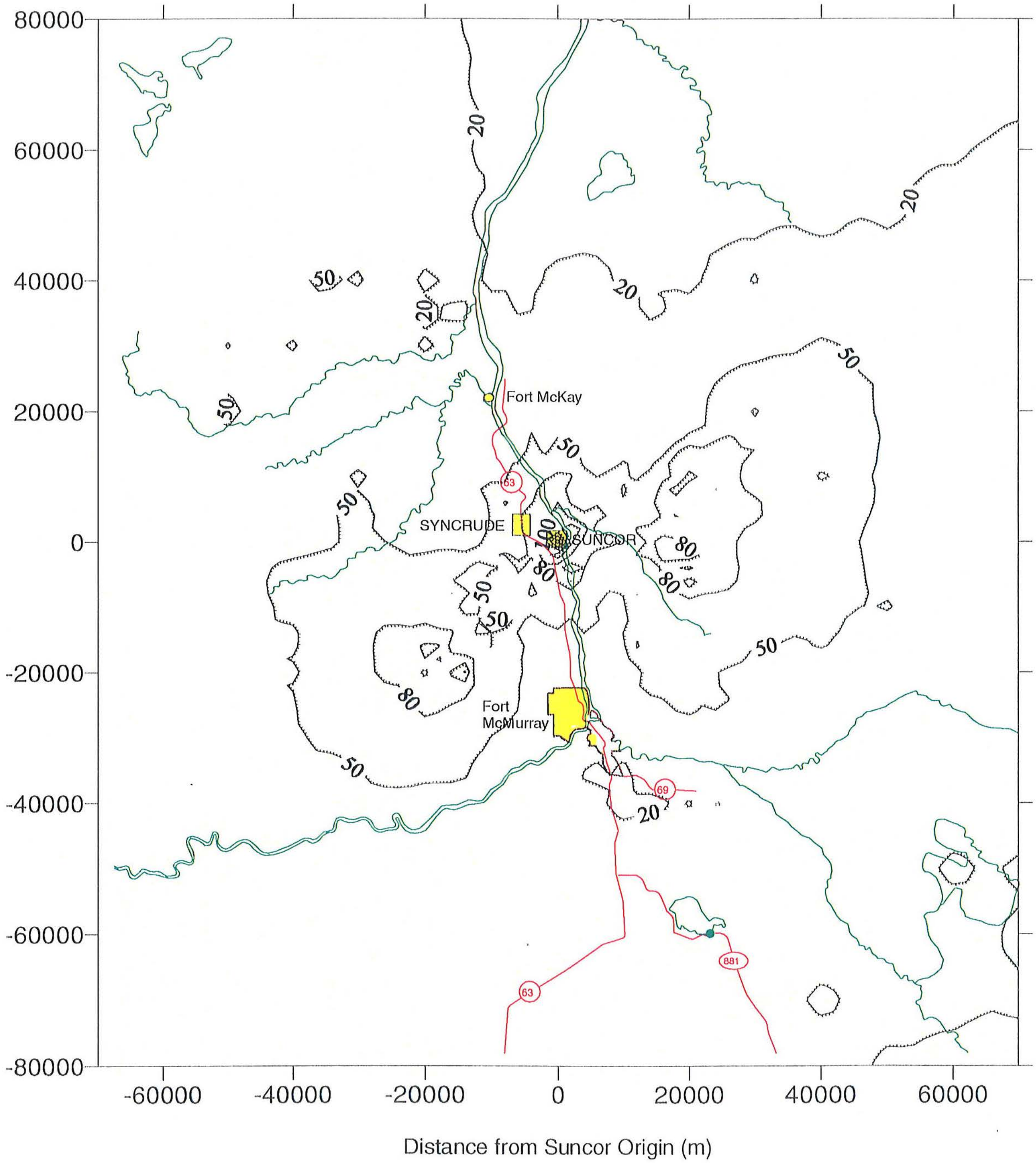


FIGURE C2.0-2

MAXIMUM PREDICTED DAILY AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE OPERATION OF THE SUNCOR FGD STACK (SO_2 EMISSIONS = 19.2 t/d)

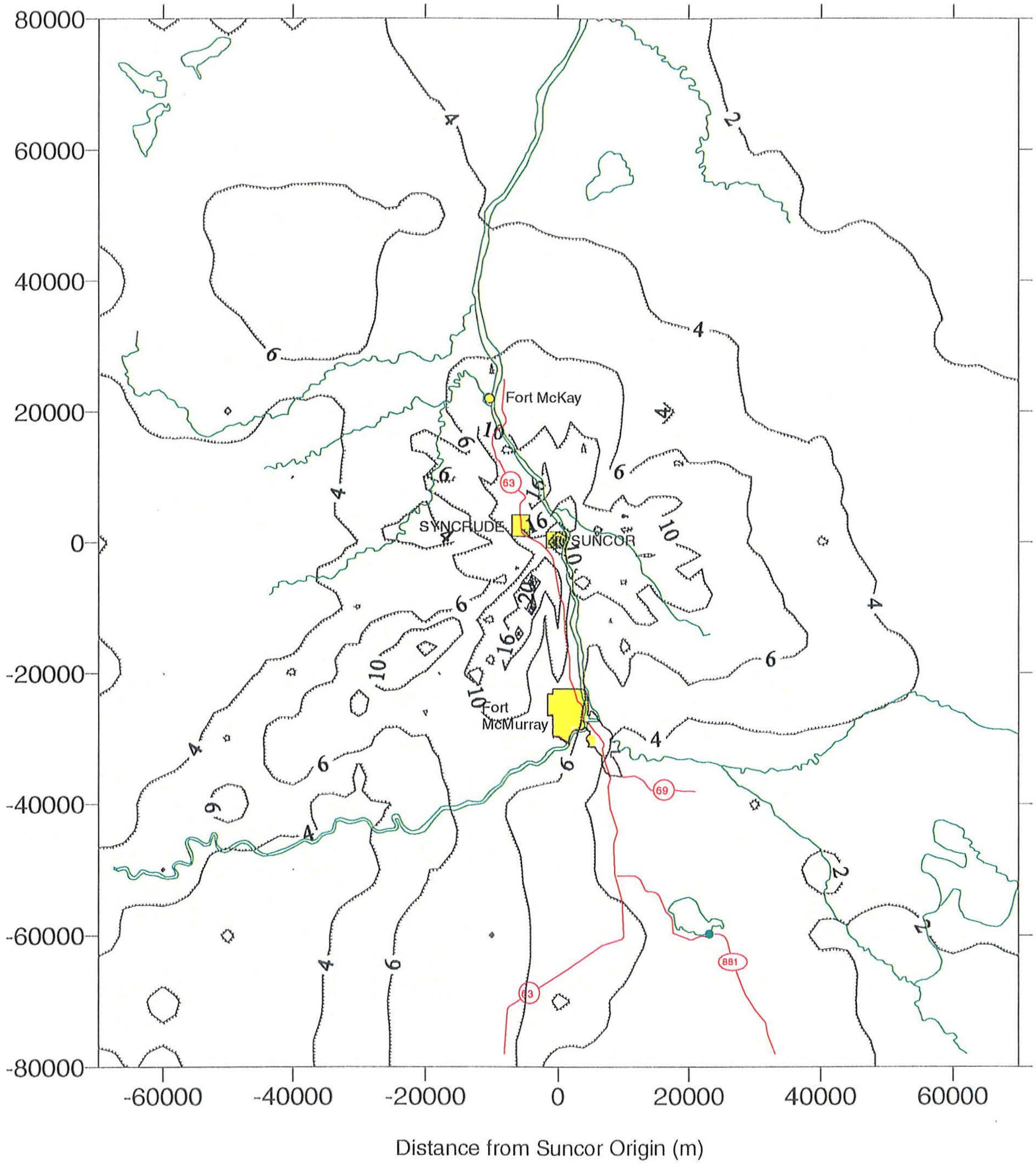


FIGURE C2.0-3

PREDICTED ANNUAL AVERAGE SO_2 CONCENTRATIONS ($\mu g/m^3$)

RESULTING FROM THE OPERATION OF THE SUNCOR FGD STACK

(SO_2 EMISSION = 19.2 t/d)

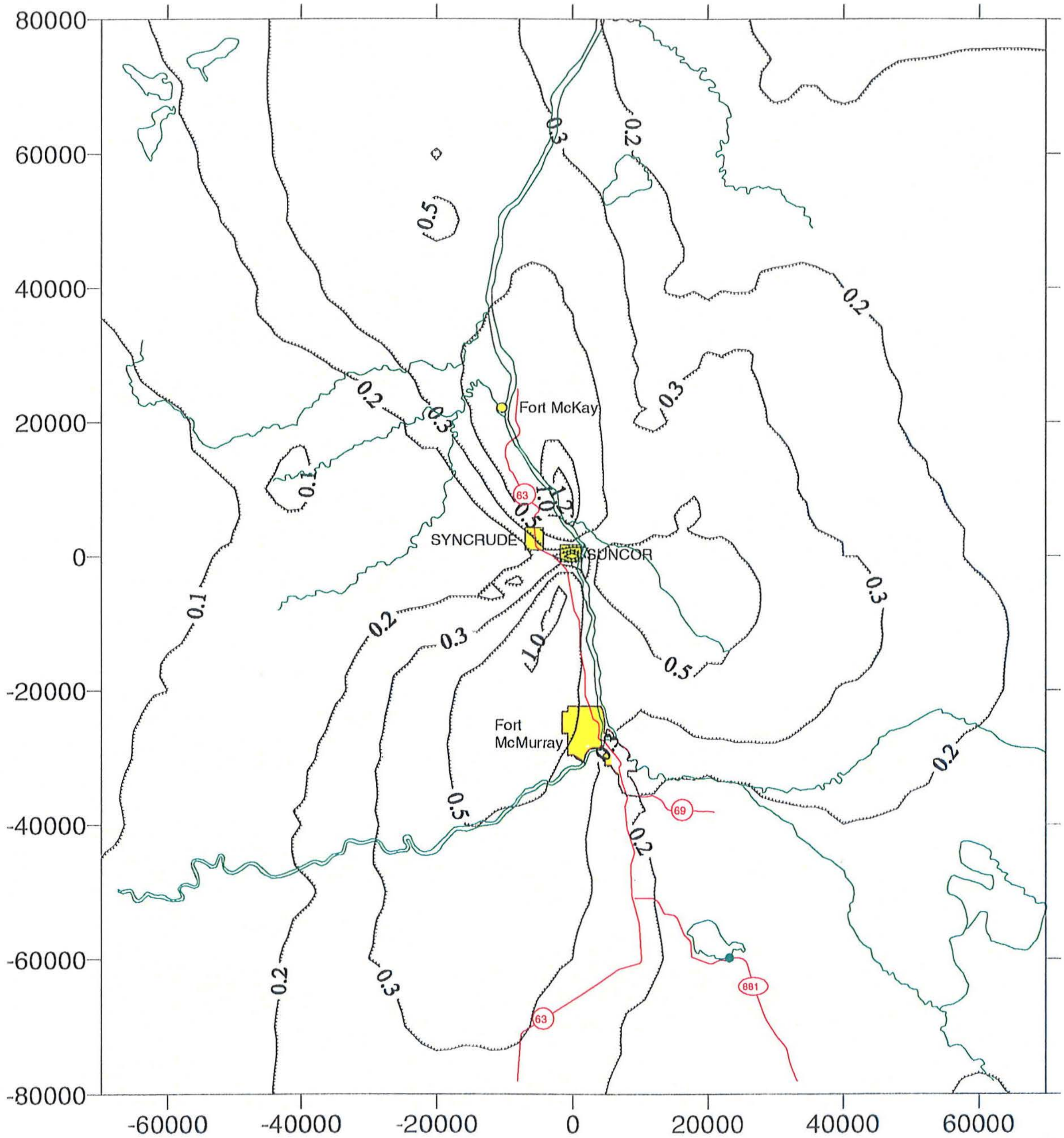


FIGURE C2.0-4

MAXIMUM PREDICTED HOURLY AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE COMBINED OPERATION OF REGIONAL SOURCES (2001 EMISSION SCENARIO)

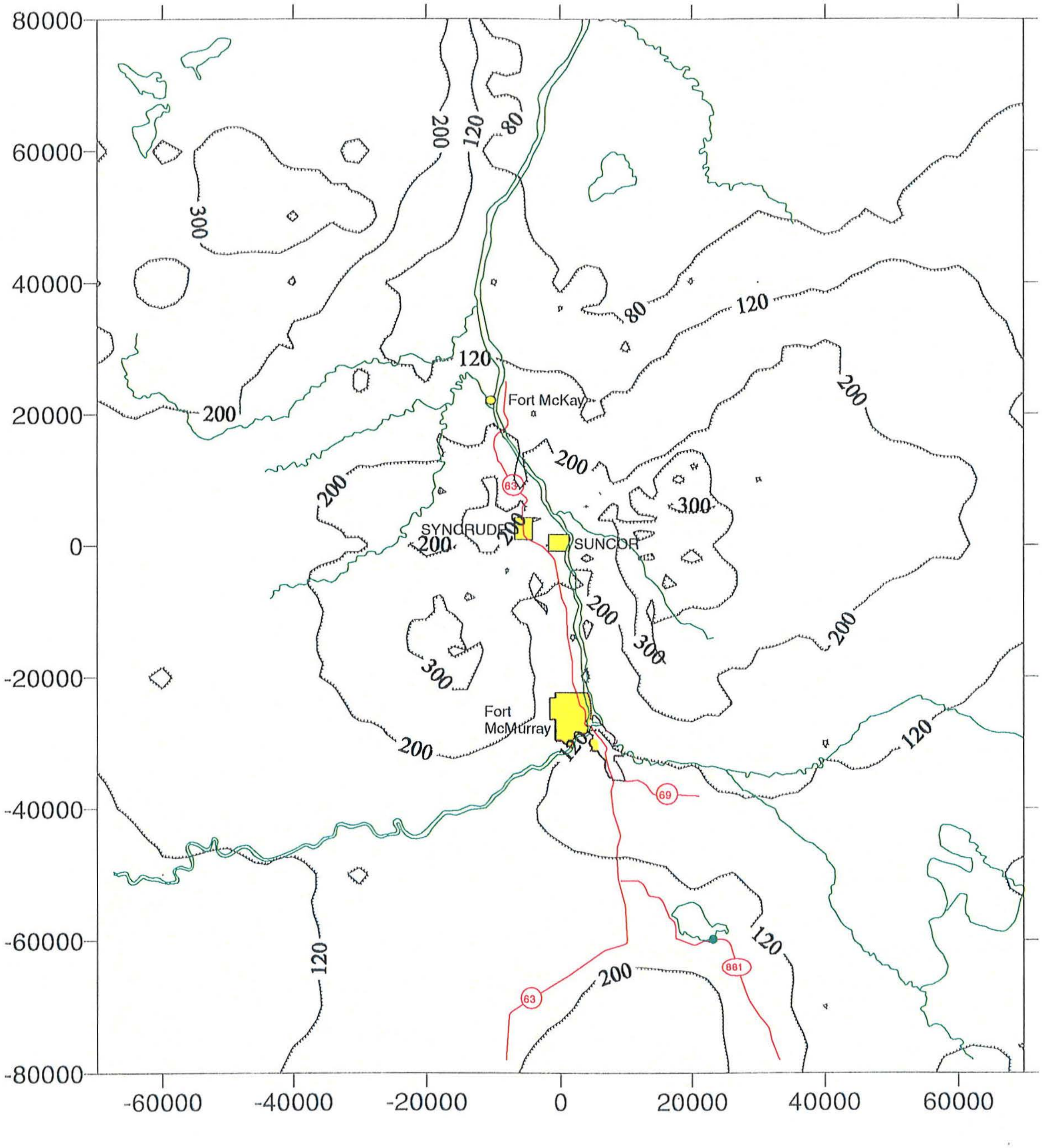


FIGURE C2.0-5

MAXIMUM PREDICTED DAILY AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE COMBINED OPERATION OF REGIONAL SOURCES (2001 EMISSION SCENARIO)

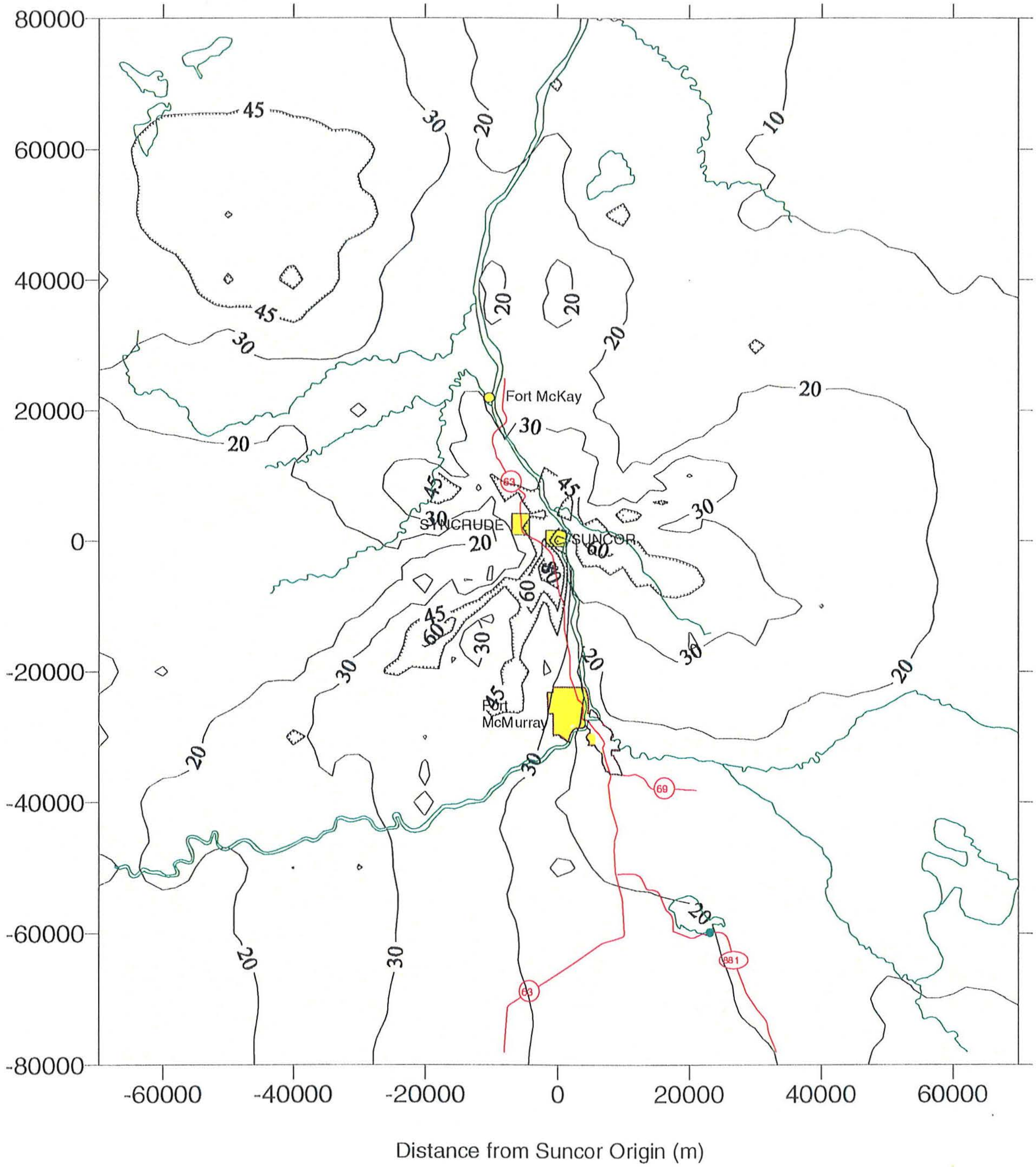


FIGURE C2.0-6

PREDICTED ANNUAL AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$) RESULTING FROM THE COMBINED OPERATION OF THE REGIONAL SO_2 SOURCES (2001 EMISSION SCENARIO)

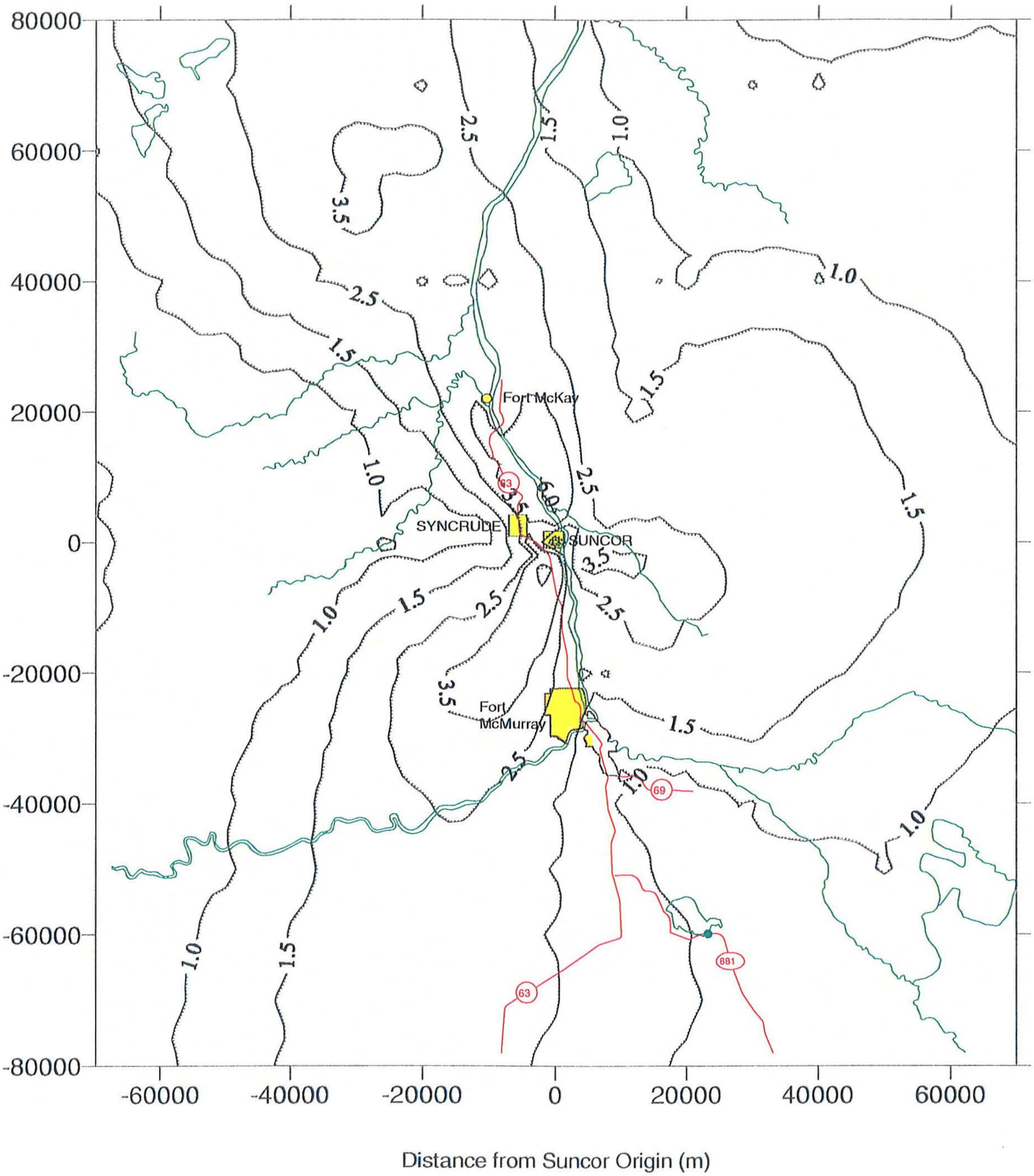


FIGURE C2.0-7

PREDICTED DRY DEPOSITION (kg SO_4^{-2}/ha/a) FROM THE OPERATION OF THE SUNCOR FGD STACK

(SO_2 EMISSIONS = 30.4 t/d)

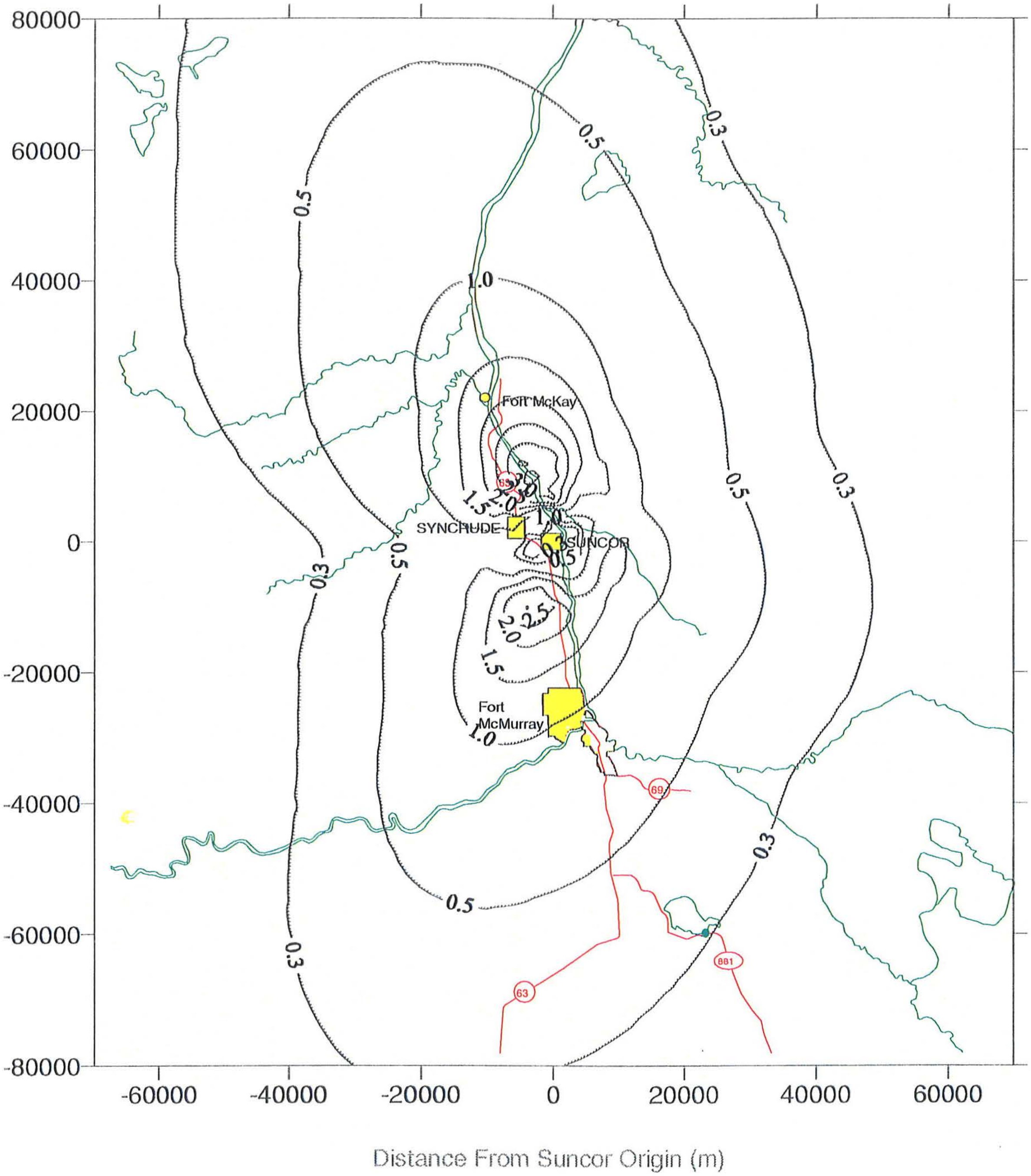


FIGURE C2.0-8

PREDICTED WET DEPOSITION (kg SO_4^{-2}/ha/a) FROM THE OPERATION OF THE SUNCOR FGD STACK

(SO_2 EMISSIONS = 30.4 t/d)

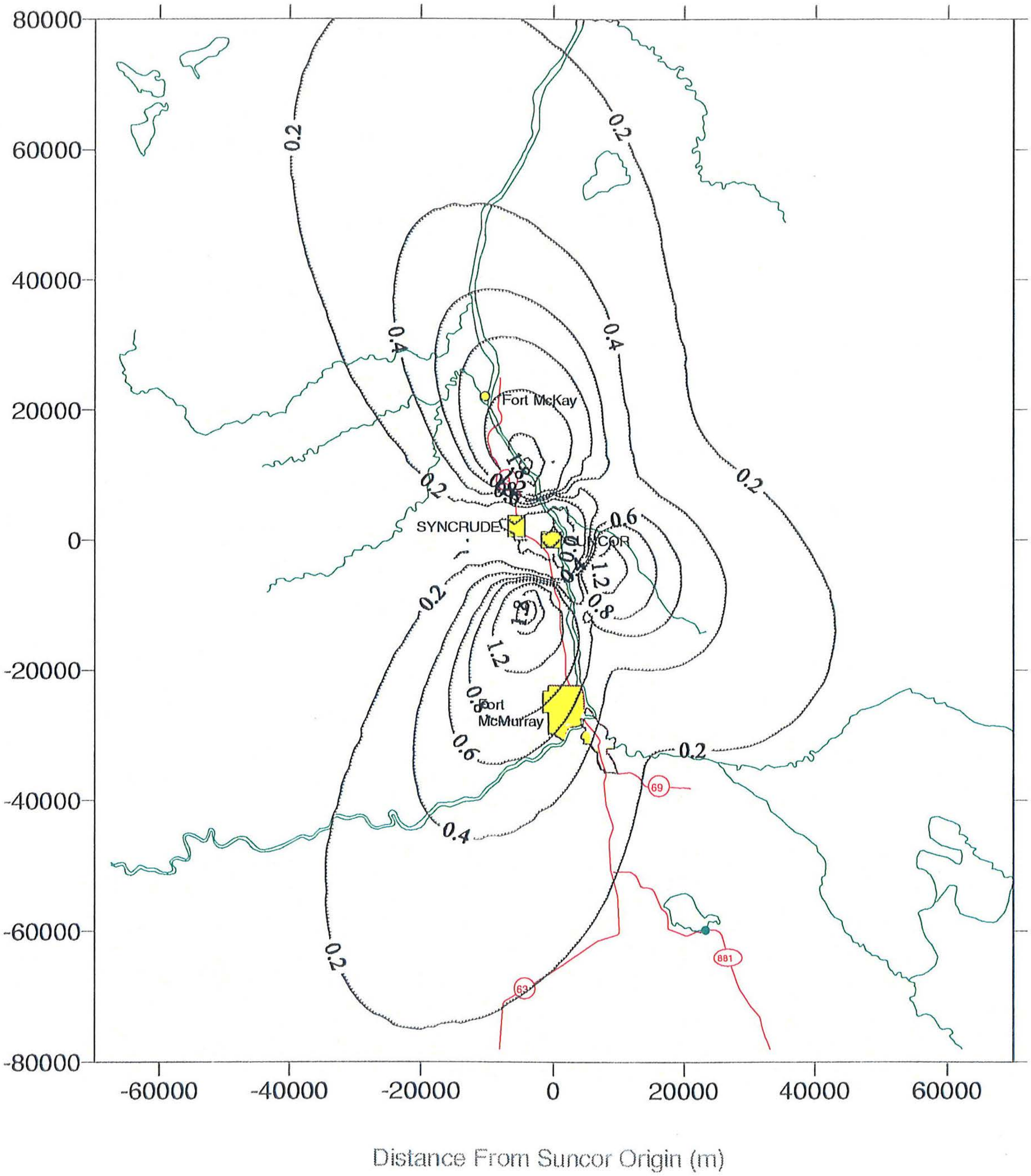


FIGURE C2.0-9

TOTAL (WET + DRY) SULPHATE DEPOSITION (kg SO_4^{-2}/ha/a) FROM THE COMBINED OPERATION OF REGIONAL SOURCES (2001 EMISSION SCENARIO)

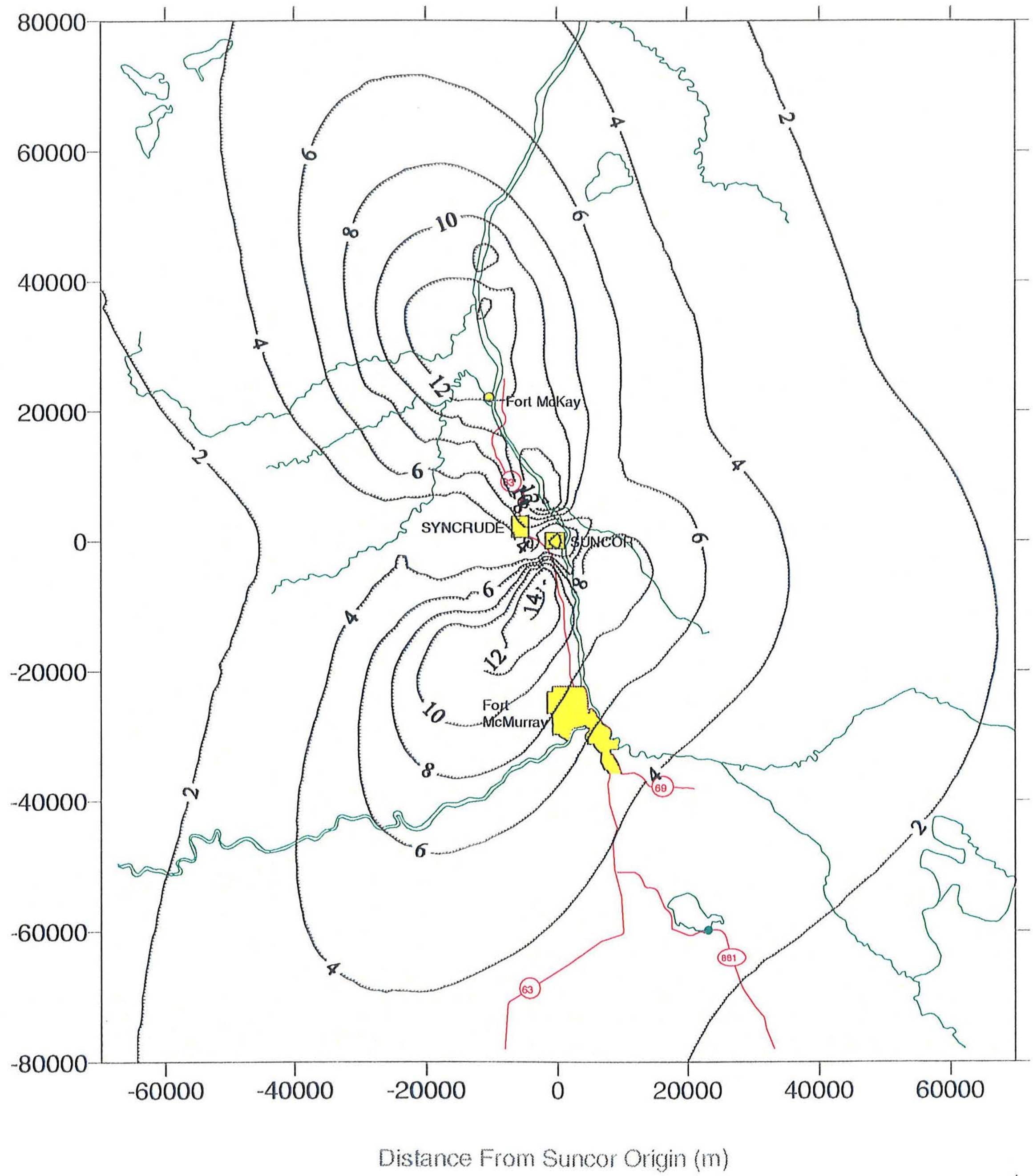
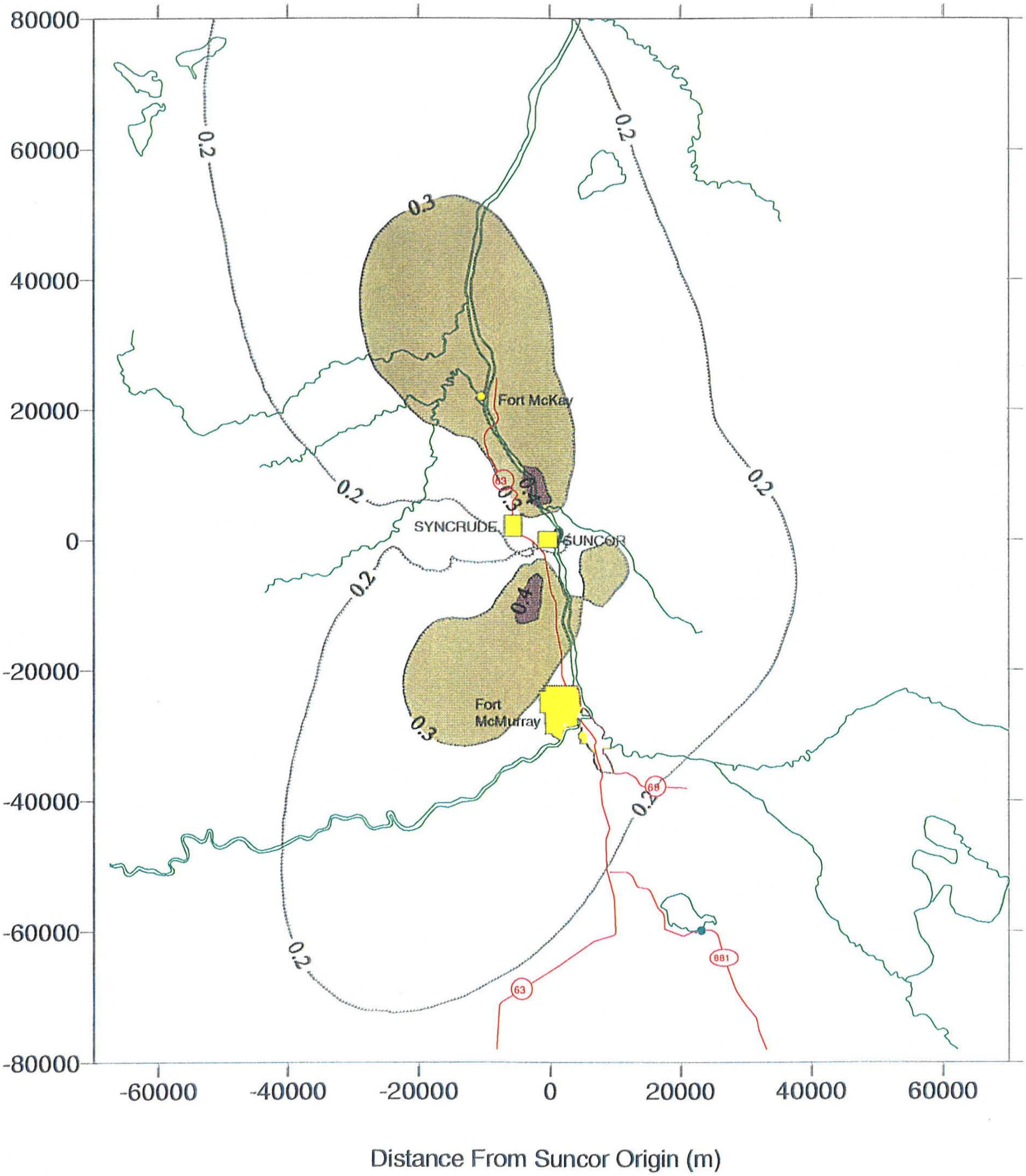


FIGURE C2.0-10

ESTIMATED EFFECTIVE ACIDITY (EA) (kmol H^+/ha/a) FROM THE COMBINED OPERATION OF REGIONAL SOURCES (2001 EMISSION SCENARIO)



APPENDIX I

ACRONYMS AND TERMS

TABLE I-1
ACRONYMS USED IN THIS AIR QUALITY ASSESSMENT REPORT

EUB	Energy and Utilities Board (formally called the Energy Resources Conservation Board (ERCB)
AEPEA	Alberta Environmental Protection and Enhancement Act
AEP	Alberta Environmental Protection
CASA	Clean Air Strategic Alliance
RAQCC	Regional Air Quality Coordinating Committee
EIA	Environmental Impact Assessment
EPA	U.S. Environmental Protection Agency
VRU	Vapour Recovery Unit
FGD	Flue Gas Desulphurization
ESP	Electrostatic Precipitation
AMSL	Above Mean Sea Level
SEC	Supplemental Emission Control
EA	Effective Acidity
WMO	World Meteorological Organization
UNEP	United Nations Environmental Program
FCCC	Framework Convention on Climate Change
CCP	Canadian Climate Program

TABLE I-2
CHEMICAL SYMBOLS USED IN THE AIR QUALITY ASSESSMENT REPORT

SYMBOL	COMPOUND
CFC	Chlorofluorocarbon
CH_4	Methane
CO_2	Carbon dioxide
COS	Carbonyl sulphide
CS_2	Carbon disulphide
H^+	Hydrogen ion
H_2O	Water
H_2S	Hydrogen sulphide
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
N_2O	Nitrous oxide
O_3	Ozone
PM	Particulate matter
PM_{10}	Particulate matter whose diameters are 10 μm or less in diameter
SO_2	Sulphur dioxide
SO_4^{-2}	Sulphate ion
THC	Total hydrocarbon
TRS	Total reduced sulphur
TSP	Total Suspended Particulate
VOC	Volatile organic compounds

TABLE I-3
UNITS USED IN THE AIR QUALITY ASSESSMENT REPORT

a	annum (year)
t	metric tonne (1000 kg)
kg	kilogram
μm	micrometre (10^{-6} m)
MW	Mega Watts (10^{6} Watts)
Gt	Giga tonnes (10^{12} tonnes)
d	day
cd	calendar day
sd	stream day
bbl	barrels
m	metre
m^2	square metre
m^3	cubic metre
°C	Celsius degrees
ha	hectare (10^4 m^2)
km	kilometre
K	Kelvin degrees
s	seconds
W	Watts
ppm	parts per million (10^{-6})
ppb	parts per billion (10^{-9})
kmol	kilo mole (1000 moles)
$\mu g/m^3$	micrograms per cubic metre
kmol H^+/ha/a	kilo moles of hydrogen ion equivalent per hectare per year
kg SO_4^{-2}/ha/a	kilograms of sulphate ion equivalent per hectare per year

TABLE I-4
SOURCE TERMS
(from Report 1: Sources of Atmospheric Emissions in the Athabasca Oil Sands Region)

Term	Definition
Airshed	A geographical region that shares one or more of the following: similar terrain, similar meteorology, similar sources, similar receptors. For the purposes of this report, the Athabasca oil sands region airshed was arbitrarily selected as the area located within 60 km of the Suncor and Syncrude oil sands operations. This airshed definition can be redefined by RAQCC.
Receptor	A biological or physical entity that is exposed to air emissions. Vegetation and humans are examples of biological receptors. Soils and water are examples of physical receptors.
Point Sources	An emission source that is described as a conventional stack, a flare stack or a process vent. Stacks and vents can range in height from a few metres to more than 100 m.
Line Sources	An emission source that can be described as single or multiple emissions that occur along a line. Dust emissions from a conveyer belt is an example of a single line source. A highway is an example of a line source that is comprised of multiple sources (i.e. vehicles).
Area Sources	An emission source that is described as occurring over a defined area. Evaporation from a pond surface is an example of a single area source. Emissions from residential heating units and vehicular traffic are examples of area sources that are comprised of multiple small emissions.
Stack Surveys	A periodic measurement taken to characterize and quantify stack emissions. Measurements for large stacks are typically taken halfway up the stack using probes. Alberta Environmental Protection and the U.S. EPA have rigourously prescribed procedures for conducting stack surveys.
CSEM	Continuous Stack Emission Monitors (CSEM) measure stack gas temperatures, exit velocities and contaminant flow rates on a continuous basis. Stack surveys are conducted to confirm satisfactory CSEM operation.

TABLE I-4
CONCLUDED

TERM	DEFINITION
Fugitive Sources	Fugitive emissions are defined as contaminants emitted from any source except those from stacks or vents. Typical sources include gaseous leakages from valves, flanges, drains, volatilization from ponds and lagoons, and open doors and windows. Typical particulate sources include bulk storage areas, open conveyers, construction areas or plant roads.
Upset Emissions	During plant start-up, shut-down and abnormal operating conditions, gas streams can be vented directly into the atmosphere prior to usual treatment. Petrochemical (gas plants, refineries) frequently use a flare stack to dispose of gas streams under these conditions. Prudent stewardship ensures both infrequent and short duration upset emissions.
Emission Factor	In the absence of measurements, industry standard emission factors can be used to estimate emissions from a wide range of sources. An emission factor is a conversion factor and can be expressed as a contaminant release rate per amount of fuel consumed.
Emission Inventory	A database identifying, characterizing and quantifying emission sources. The database can provide spatial and temporal variation.
Stream day / Calendar day	Emissions of a pollutant are often expressed on a mass per unit time basis, for example, tonnes per day which can be abbreviated as t/d. Process engineers often distinguish between tonnes per stream day (t/sd) which is the emission rate based on the period when the facility is operating and tonnes per calendar day, which is the average over the full period (e.g., a full 365 day year). The emission rate expressed on a t/sd basis will be larger than that expressed on a t/cd basis due to averaging.
Julian Day	A designation that identifies the day of the year by using a number between 1 and 365 (366 for leap years). For example, Julian day 1 = January 1, Julian day 365 = December 31.

TABLE I-5
AIR QUALITY TERMS
(from Report 2: Ambient Air Quality Observations in the Athabasca Oil Sands Region)

TERM	DEFINITION
Air Quality	A description of the type and amount of trace constituents in the ambient air that can be described as a contaminant. A contaminant (or pollutant) has the connotation of being derived from human activities.
Ambient Air	Ambient air refers to that portion of the atmosphere that can be described as the breathing zone for the inhabitants of the earth's surface. Contaminants contained in the ambient air are of concern because of their potential effects on human health, vegetation and materials. Ambient air does not usually include air quality in the workplace or in residences.
Ambient Air Quality Guidelines	An ambient air quality guideline is a numerical concentration intended to prevent deterioration of air quality. A guideline is generally based on the lowest-observable-effect on a sensitive receptor and is usually specified by a regulatory agency.
Airshed	A geographical region that shares one or more of the following: similar terrain, similar meteorology, similar sources, similar receptors. For the purposes of this report, the Athabasca oil sands region airshed was arbitrarily selected as the area located within 60 km of the Suncor and Syncrude oil sands operations. This airshed will likely be redefined by RAQCC.
Concentration	The amount of a given component of the atmosphere is usually expressed as a concentration on a volume basis as percent (%), parts per million (ppm) or parts per billion (ppb) or on a mass basis as micrograms per cubic metre of air ($\mu g/m^3$) or milligrams per cubic metre of air (mg/m^3).
Receptor	A biological or physical entity that is exposed to air emissions. Vegetation and humans are examples of biological receptors. Soils and water are examples of physical receptors.
Continuous Monitoring	A continuous monitoring station is comprised of commercially available analyzers enclosed in a heated/air conditioned shelter. An ambient air stream is drawn past a fast response detector whose electrical response is proportional to the concentration of a selected contaminant in the gas stream. The continuous concentration information is commonly summarized as one-hour averages.

TABLE I-5
CONCLUDED

TERM	DEFINITION
Passive Monitoring	A passive monitoring station is comprised of a reactive surface that is commonly exposed to the ambient air for a nominal 30 day period. At the conclusion of the exposure period, the reactive material is analyzed to provide a measure of exposure.
Deposition	The contaminant removal rate from the atmosphere and precipitation chemistry relate to the long-term deposition of contaminants and potential acidifying effects (that is "acid rain") on surface water and soil systems. The sum of dry and wet deposition provides the cumulative loading to an ecosystem.
Dry Deposition	Contaminants can be removed from the atmosphere by direct contact with surface features (such as vegetation). This process is referred to as dry deposition and is usually expressed as a flux in units of kg/ha/a (kilograms of contaminant per hectare of land surface area per year (annum)).
Wet Deposition	Contaminants can also be removed from the atmosphere by precipitation. The precipitation chemistry is defined by the concentrations of various chemical species in the precipitation. These chemical species can result from naturally occurring particulate and gaseous compounds as well as from pollutant emissions. Wet deposition is expressed in the same units as dry deposition.
Precipitation Chemistry	Trace gases and particulates in the atmosphere can be dissolved in water droplets that ultimately form precipitation. The composition of the precipitation will be comprised of compounds consisting of positively charged anions and negatively charged cations.

TABLE I-6
METEOROLOGY TERMS
(from Report 3: Meteorology Observations in the Athabasca Oil Sands Region)

TERM	DEFINITION
Atmospheric Boundary Layer	The vertical extent to which the daytime heating and nighttime cooling cycle influences atmospheric behaviour. This is the layer closest to the earth's surface, and within which pollutants are released and dispersed.
Atmospheric Dispersion	Gases and small particles released into the atmosphere become dispersed or separated by random eddy motions or turbulence. Turbulence results in the dilution of a plume as it is mixed with the ambient air and carried downwind from the release point.
Season	For the purposes of this report, the four seasons are defined as fixed three month periods: winter is defined by December, January and February; spring is defined by March, April and May; summer is defined by June, July and August; and fall is defined by September, October and November.
Wind Direction	The direction of the mean air flow over a given averaging period. The wind direction is expressed between 0 and 360 degrees and is the direction from which the wind is blowing. For example, a 90° wind is blowing from the east.
Wind Speed	The wind speed is frequently reported in either kilometres per hour (km/h) or metres per second (m/s) (note: 1 m/s = 3.6 km/h). Wind speeds generally increase with increasing height above the ground because of reduced frictional effects between the air motion and the surface of the earth.
Power Law Exponent	A power-law relationship used to extrapolate wind speeds from a measured level to a level at which no information is available.
Surface Roughness	The surface roughness length characterizes the roughness of a surface and forms the boundary layer in dispersion models and is used to determine wind speed profiles.
Horizontal Turbulence	The random turbulent motions that produce the crosswind spread of a plume as it moves downwind. The standard deviation of the wind direction provides a measure of the horizontal turbulence. The standard deviation is often expressed as σ_θ (sigma theta) in units of degrees.

TABLE I-6
CONTINUED

TERM	DEFINITION
Vertical Turbulence	The random turbulent motions that produce the vertical spread of a plume as it moves downwind. Vertical spread below the plume centreline results in a plume being brought down to surface. The standard deviation of the vertical wind angle is expressed as σ_ϕ (sigma phi) in units of degrees.
Stability Class	A method of classifying the level of turbulence generation (or suppression) in the atmosphere. Pasquill-Gifford (PG) stability classes range from unstable (Classes A, B and C) through neutral (Class D) to stable (Classes E and F).
Unstable Conditions	Periods when convective turbulence dominates. Unstable conditions are characterized by strong daytime heating and low wind speed conditions.
Neutral Conditions	Periods when mechanical turbulence dominates. Neutral conditions are characterized by high wind speeds.
Stable Conditions	Periods when turbulence is suppressed by the radiation cooling of the earth's surface during the night. Stable conditions are characterized by clear skies and low wind speed conditions. Mechanical turbulence dominates in a layer 5 to 100 m in depth during stable conditions.
Friction Velocity	This is a velocity based on surface stress. The friction velocity is representative of turbulence fluctuations in the lowest layer of the atmospheric boundary layer.
Monin-Obukhov Length	This is the height at which the generation or suppression of thermal turbulence by heating or cooling is equal to the generation of turbulence by mechanical means.

TABLE I-6
CONTINUED

TERM	DEFINITION
Temperature Gradient	Temperature normally decreases with increasing height above the earth's surface. Temperature gradients are defined as positive for decreasing values with increasing heights and negative for increasing values with increasing heights. The temperature gradient is expressed in units of degrees Kelvin per metre of elevation (K/m). For neutral atmospheric conditions, this rate of cooling is about 1 C° (1 K) for every 100 m in elevation increase (e.g., 0.01 K/m). During unstable conditions, the temperature gradients are greater than 0.01 K/m, (e.g., 0.03 K/m). During stable conditions, the temperature gradients are less than 0.01 K/m (e.g., -0.01 K/m).
Potential Temperature Gradient	A value of 0.01 K/m is added to the temperature gradient to "normalize" the temperature gradient. Neutral atmospheres are therefore characterized by a potential temperature gradient of 0.0 K/m. Positive potential temperature gradient values correspond to unstable conditions, while negative values correspond to stable conditions.
Net Radiation	Net radiation is defined as the difference between the incoming radiation from the sun and the outgoing radiation from the earth's surface. During the day, net radiation is positive and during the night net radiation is negative. Net radiation provides a measure of the production of convective turbulence during the day and the suppression of turbulence by cooling during the night.
Inversion	A stable atmospheric condition caused when the temperature increases with increasing height above the ground. An elevated inversion can produce a barrier that inhibits vertical dispersion and hence acts as a lid.
Mixing Height	A near-neutral or convective layer near the ground that is capped by an inversion. The mixing height can vary from typical nighttime values of 100 to 200 m to daytime values of up to 1000 to 2000 m during the day.
Mechanical Turbulence	Turbulence created by the action of the wind blowing over a rough irregular surface. Mechanical turbulence is greatest with a rough surface and high wind speeds.

TABLE I-6
CONCLUDED

TERM	DEFINITION
Mechanical Mixing Height	The turbulent layer that is produced by mechanical interaction of wind with the earth's surface. The mixing height is determined by mechanical processes during the night and during the day when high wind speeds occur.
Convective Turbulence	Turbulence in the atmosphere can be created by the sun heating the earth's surface. Convective turbulence is greatest on a hot summer day.
Convective Mixing Height	The turbulent layer that is produced by convective activity resulting from daytime surface heating. The mixing height is dominated by convective processes during the day under strong solar heating conditions.

TABLE I-7
MODELLING TERMS
(from Report 4: Ambient Air Quality Predictions in the Athabasca Oil Sands Region)

TERM	DEFINITION
Model	A model is a simplified representation of reality. It is simplified because we cannot deal with all the variables that affect the environment. Models are usually comprised of mathematical relationships between the important variables.
Dispersion Model	A set of mathematical relationships that are used to describe the rise of a plume and the subsequent dispersion of the plume as it is transported by the wind. When these relationships are coded for use by a computer, the model is referred to as a computer model. Computer models, like people, are given names (e.g., SCREEN3, ISCST3, ADEPT2).
Spatial Scale	Can be defined as the distance from the source to a receptor. Typical spatial scales are as follows: • Site specific: 0 to 250 m. • Local: 250 m to 20 km. • Mesoscale: 20 to 500 km. • Long-range: 500 to 1000 km • Hemispheric • Global The criteria delineating different scales can vary with practitioner.
Temporal Scale	Can be defined as the response time of an exposed receptor and/or the travel time from source to receptor. Typical temporal scales are: • Instantaneous (seconds to minutes) • Hourly (short-term) • Daily (short-term) • Seasonal (growing season) • Annual (chronic low-level exposures) Hourly, daily and annual from the basis of ambient air quality guidelines.
Deposition Velocity	A proportionally constant that can be used to convert an ambient concentration into a deposition flux. Deposition velocities vary with meteorology, pollutant and receptor activity. The latter will result in differing deposition velocities for different vegetation canopies.

TABLE I-7
CONCLUDED

TERM	DEFINITION
Stability Class	A method of classifying the level of turbulence in the atmosphere. Pasquill-Gifford (PG) stability classes range from unstable (Classes A, B and C) that can occur during the daytime through to neutral (Class D) that can occur day or night to stable (Classes E and F) that can occur at night.
STAR	Stability Array. A joint frequency distribution of wind speed (6 classes), wind direction (16 directions) and stability class (6 classes) whose sum for each season adds up to unity (1.000). STAR data are used by climatological models such as ADEPT2.
Terrain Effects	Terrain can influence the overall horizontal and vertical trajectory of a plume. Terrain can also increase turbulence levels due to its roughness.
Plume Rise	Gases exiting from a stack can rise due to momentum and/or buoyancy effects before the wind bends the plume over into a horizontal trajectory.
Location	The location of the maximum predicted concentrations relative to a given source is given in polar coordinates: distance and angle. The distance is expressed in kilometres (km) from the source and the angular value is based on direction. A 90° direction indicates a location to the east of the source; a 180° direction indicates a location to the south of the source; and so on.