AN INVENTORY SYSTEM FOR ATMOSPHERIC EMISSIONS IN THE AOSERP STUDY AREA

by

W. SHELFENTOOK
SNC Tottrup Services Ltd.
Edmonton, Alberta

for

ALBERTA OIL SANDS
ENVIRONMENTAL RESEARCH PROGRAM

Project ME 2.2

May 1978

TABLE OF CONTENTS

		Page
DECLARATION		ii
LETTER OF TRANSMITTAL		iii
DESCRIPTIVE SUMMARY		iv
LIST OF TABLES		xi
LIST OF FIGURES		xii
ABSTRACT		xiii
ACKNOWLEDGEMENTS		xiv
1.	INTRODUCTION	1
2.	SUMMARY OF EMISSIONS, 1976	4
3.	DATA STORAGE AND RETRIEVAL SYSTEM	16
3.1	Information Retained by the System	16
3.1.1	Source Identification	16
3.1.2	Source Description	17
3.1.3	Physical Characteristics	17
3.1.4	Temporal Variation Parameters	17
3.1.5	Emission Values	17
3.2	System Input and Updating	19
3.3	Report Generation Capability	19
4.	DETERMINATION OF EMISSION SOURCES	21
5.	EMISSION OF POLLUTANTS	22
6.	PROJECTED EMISSIONS, 1976 THROUGH 1985	23
6.1	Overall Development Scenario	23
6.2	Projected Sulphur Dioxide Emissions	24
6.3	Projected Carbon Monoxide Emissions	24
6.4	Projected Emissions of Organic Materials	31
6.5	Projected Emissions of Oxides of Nitrogen	31
6.6	Projected Particulate Emissions	31
6.7	Projected Water Vapor Emissions	32
7.	FORMS, ASSOCIATIONS, AND COMPLEXES OF SUBSTANCES EMITTED TO THE ATMOSPHERE	33
7.1	Sulphur Compounds	33
7.2	Nitrogen Compounds	34
7.3	Organics	34
7.4	Particulates	35
7.4.1	Primary Particulates	35
7.4.2	Secondary Particulates	35

TABLE OF CONTENTS (CONCLUDED)

Page

8. ANALYSIS OF FLY ASH SAMPLES FROM GCOS 37

9. RECOMMENDED FUTURE WORK 40

10. REFERENCES CITED 41

11. APPENDICES 44
11.1 Sample Input Documents 44
11.2 Sample Report Generator Input with Reports Generated 54

12. AOSERP RESEARCH REPORTS 57

LIST OF TABLES

Page

1. Summary of Emissions from Great Canadian Oil Sands, 1976 5
2. Summary of Emissions from Syncrude, Texaco and AMOCO, 1976 6
3. Summary of Emissions from Fort McMurray, 1976 7
4. Summary of Emissions from Undeveloped Areas, 1976 8
5. Summary of Emissions from All Sources, 1976 9
6. Analytical Procedures Employed for Fly Ash Analyses ... 38
7. Analytical Results of GCOS Fly Ash Samples, Wt. % as Element (or as noted) 39

LIST OF FIGURES

Page

1. The Alberta Oil Sands Environmental Research Program Study Area 2
2. Sulphur Dioxide Emissions, 1976, Breakdown by "Ownership". 10
3. Carbon Monoxide Emissions, 1976, Breakdown by "Ownership". 11
4. Total Organic Emissions, 1976, Breakdown by "Ownership" .. 12
5. Oxides of Nitrogen Emissions, 1976, Breakdown by "Ownership" 13
6. Particulate Emissions, 1976, Breakdown by "Ownership" 14
7. Water Vapor Emissions, 1976, Breakdown by "Ownership" 15
8. Project Study Area with UTM Grid Overlay 18
9. Projected SO_2 Emissions - Man Made Sources 25
10. Projected CO Emissions - Man Made Sources 26
11. Projected Total Organic Emissions - Man Made Sources 27
12. Projected NO_x Emissions - Man Made Sources 28
13. Projected Particulate Emissions - Man Made Sources 29
14. Projected Water Vapor Emissions - Man Made Sources 30

ABSTRACT

This report describes the inventory system developed to provide a comprehensive data base for emission of materials to the atmosphere which are judged to be of environmental concern in the AOSERP study area.

A detailed evaluation of man-related activities and natural processes within the area was made, and the accumulated data entered into a computerized data retrieval system. The system has the capability to add, delete, change, and report information by a variety of selection criteria. The inventory system is operated by Alberta Environment, Air Quality Control Branch.

An evaluation of the data shows organic emissions to be largely of natural origin. In addition, natural sources contribute substantial quantities of oxides of nitrogen and ammonia. For all other emissions considered, man-related activities accounted for most; industrial development was the prime cause.

Estimated values of emissions from natural sources has been identified as an area where further study is required to develop better precision.

ACKNOWLEDGEMENTS

This research project ME 2.2 was funded by the Alberta Oil Sands Environmental Research Program, a joint Alberta-Canada research program established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta.

1. INTRODUCTION

The objective of this study is to provide a comprehensive compilation of all identifiable sources of emissions to the atmosphere that are judged to be environmentally significant in the Alberta Oil Sands Environmental Research Program (AOSERP) study area (Figure 1). To meet this objective successfully it has been necessary to consider virtually all processes, natural and otherwise, occurring within the study area and evaluate their environmental consequences.

From lists of major activities and subactivities and estimates of emissions related to various sources, a comprehensive data file was developed. The large volume of data was handled most conveniently by a computerized data retrieval system. However, computerizing the system required regimentation of the data to a standard format and for this reason information requirements for each emission source was broken down into the following sections:

1. What is the source? This included both a brief description of the activity causing the emissions and information regarding the physical nature of the source.
2. Where is it located? By means of the metric civilian grid overlayed on the 6^{o} UTM projection the co-ordinates locating the source are given in a square sized appropriate to the physical size or distribution of the source, with point sources defined as a one metre square. Sources distributed over an area are defined by 10 metre, 100 metre or one kilometre squares.
3. What is the variation with time? To provide information on the variation of emissions with time, a set of temporal variation parameters are provided for each source which estimate seasonal changes in emissions as well as maximum monthly, daily, and instantaneous rates.

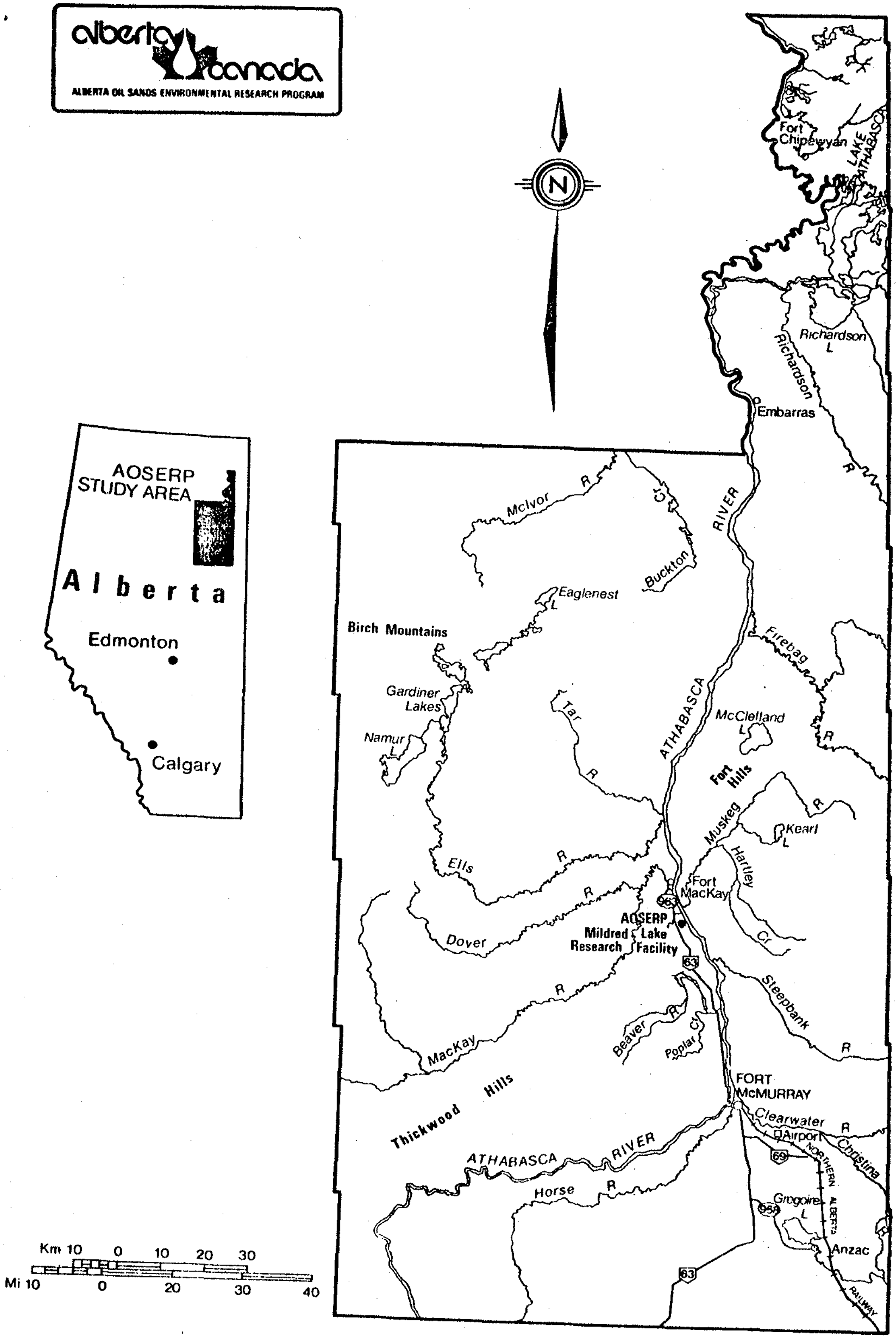


Figure 1. The Alberta Oil Sands Environmental Research Program study area.

4. What emissions and quantities? For each source, each material emitted is identified by a code with a quantity in metric units associated with each. A magnitude factor is also included allowing for mass units ranging from milligrams (10^{-3}g) to gigagrams (10^{9}g). The implied time base for all emission values is one year.

2. SUMMARY OF EMISSIONS, 1976

Tables 1 through 5 summarize the quantities of materials emitted from all sources for the year 1976 which were identified by this study. The first four tables show the emissions broken down by ownership and, in some cases, the activities identified for the different owners. Table 5 summarizes all emissions from all sources. Note that 10^6g = 1 tonne, and 10^9g = 1 gigagram.

Figures 2 through 7 give the breakdown of the six major emissions according to "ownership" for 1976 emissions. Two figures are provided for each, the first including natural sources and the second only those emissions from man made sources.

The data presented are those stored in the computerized data base at the present time; these data represent the base estimates currently available. For major sources, reasonable accuracy is ensured by the use of analytical data and measured flow rates. For the many minor sources, the use of factors from utilization parameters (e.g., fuel consumption) gives better than order of magnitude accuracy to the estimates.

The emission values with potentially the largest errors are those attributed to natural sources. There are no available data on natural emissions for the vegetation and climatic conditions of the study area. Prorating global emission estimates likely introduces large errors but in the absence of data specific to this area, represents the best available approach.

Table 1. Summary of emissions from Great Canadian Oil Sands, 1976.

ACTIVITY GROUP	SO_2	H_2S	CO	LIGHT HC (AS CH_4)	RCHO (AS HCHO)	HEAVY ORGANICS	ORGANIC ACIDS	NH_3	NO_x (AS NO_2)	PARTI-CULATES	WATER VAPOR
	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^9 g$
LEASE DEVELOPMENT EMISSIONS											
Natural Sources		13.05		55.1		203.		203.	137.75		9425.00
Overburden Removal	8.65		25.62		2.14	8.32			145.32	916.87	0.37
Misc. Sources	0.93		675.52		0.79	142.88			16.37	1.02	1.15
Sub-Total	9.58	13.05	701.14	55.1	2.93	354.20		203.	299.44	917.89	9426.52
EXTRACTION AREA EMISSIONS											
Primary						170.60					251.80
Final						965.50					11.87
Tailings Handling						115.00					36.40
Sub-Total						1251.1					300.07
UPGRADING AREA EMISSIONS											
Coking Plant	1.47			51.82	5.18				399.60	34.54	180.97
H_2 Plant	13.21			85.60	8.61				660.20	57.10	446.21
Hydrotreating Plant	0.61			21.70	2.17				167.40	14.48	75.50
Sulphur Recovery	9330.00			5.70	0.57	2053.5			44.10	3.80	128.00
Liquid Storage											
Flares	4680.20			6.16	0.61				47.50	93.30	22.70
Sub-Total	14025.49			170.98	17.14	2053.5			1318.80	203.22	853.38
UTILITIES & SERVICES EMISS.											
Steam Plant	79000.00		319.00	95.60	1.59				5734.00	14370.00	994.00
Oil Recovery System						102.00					
Cooling & Effluent Ponds						808.50					195.78
Tailings Ponds						64.03					1482.48
Sub-Total	79000.00		319.00	95.60	1.59	974.53			5734.00	14370.00	2672.26
MISCELLANEOUS SOURCES											
Mobile Emissions	0.99		33.32	4.38	0.12		0.12		16.17	0.78	0.45
Sub-Total	0.99		33.32	4.38	0.12		0.12		16.17	0.78	0.45
GRAND TOTAL	93036.06	13.05	1053.46	326.06	21.78	4633.33	0.12	203.	7368.41	15491.89	13252.68

Table 2. Summary of emissions from Syncrude, Texaco, and AMOCO, 1976.

OWNER	SO_2	H_2S	CO	LIGHT HC (AS CH_4)	RCHO (AS HCHO)	HEAVY ORGANICS	ORGANIC ACIDS	NH_3	NO_X (AS NO_2)	PARTICULATES	WATER VAPOR
	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^9 g$
SYNCRUDE											
Natural Sources		84.15		355.30		1309.		1309.	888.25		60775.00
Mobile Equipment	44.38		629.67	1.20					11.96	2.84	0.87
Camp Heating	.09		3.00	56.30	11.20		0.18		731.80	31.39	11.32
Sub-Total	44.47	84.15	632.67	412.8	11.20	1309.	0.18	1309.	1632.01	34.23	60787.19
AMOCO											
Steam Genertor	110.00		7.77	5.44					149.00	42.71	14.82
Process Gas Incinerator	.05		1.53	.27					10.87	1.64	9.45
Sub-Total	110.05		9.30	5.71					159.87	44.35	24.27
TEXACO											
Steam Generation	0.11		3.04	0.54					21.64	3.27	18.82
Sub-Total	0.11		3.04	0.54					21.64	3.27	18.82
GRAND TOTAL	154.63	84.15	645.01	419.05	11.20	1309.	0.18	1309.	1813.52	81.85	60830.28

Table 3. Summary of emissions from Fort McMurray, 1976.

	SO_X (AS SO_2)	H_2S	CO	LIGHT HC (AS CH_4)	RCHO (AS HCHO)	HEAVY ORGANICS	ORGANIC ACIDS	NH_3	NO_X (AS NO_2)	PARTIC-ULATES	WATER VAPOR
	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^9 g$
NATURAL SOURCES		22.95		96.90		357.00		357.00	242.25		16575.00
SPACE HEATING EMISSIONS											
Lower town	0.17		5.41	2.17					21.66	5.11	28.09
Area 2	0.04		1.43	0.57					5.73	1.35	7.44
Area 5	0.06		2.24	0.90					8.93	2.10	11.57
Area 6	0.04		1.27	0.51					5.10	1.20	6.61
Sub-Total	0.31		10.35	4.15					41.42	9.76	53.71
VEHICLE EMISSIONS											
Lower town	2.95		312.12			44.98			100.98	8.84	3.65
Area 2	0.76		80.24			11.56			25.96	2.28	0.94
Area 5	1.19		124.85			17.99			40.40	3.54	1.46
Area 6	0.67		71.34			10.28			23.08	2.02	0.83
Construction Equip.	19.81		62.50		6.14	26.80			265.92	17.31	4.61
Highway 63	5.12		197.15	26.09	0.57		0.57		88.58	4.67	2.54
Sub-Total	30.50		848.20	26.09	6.71	111.61	0.57		544.92	38.66	14.03
COMMERCIAL AND INDUSTRIAL											
Gasoline Marketing						45.75					
Bulk Oil Storage						208.15					
Drycleaning Plants						21.53					
Ready Mix Concrete										3.58	
Gravel Processing										22.05	
Keyano College	1.78		5.62		0.55	2.41			23.91	5021.56	0.42
Alberta Power	2.34								271.00	2.47	
Swanson Lumber	0.21		278.00			23.55			2.14	15.00	2.57
Sub-Total	4.33		283.62		0.55	301.39			297.05	5064.66	2.99
GRAND TOTAL	35.14	22.95	1142.17	127.14	7.26	770.00	0.57	357.00	1125.64	5113.08	16645.73

Table 4. Summary of emissions from undeveloped areas, 1976.

SOURCE ACTIVITY	SO_x (AS SO_2) 10^6g	H_2S 10^6g	CO 10^6g	LIGHT HC 10^6g	RCHO (AS HCHO) 10^6g	HEAVY ORGANICS 10^6g	ORGANIC ACIDS 10^6g	NH_3 10^6g	NO_x (AS NO_2) 10^6g	PARTIC-ULATES 10^6g	WATER VAPOR 10^9g
FOREST EMISSIONS											
AFS Zone L6		85.5		361.00		1330.		1330.	902.5		61750
" " A1		588.6		2485.2		9156.		9156.	6213.0		425100
" " A2		427.5		1805.0		6650.		6650.	4512.5		306750
" " A3		1976.0		8342.9		30737.		30737.	20857.3		1410500
" " A4		887.4		3746.8		13804.		13804.	9367.0		640900
" " A5		1773.0		7486.0		27580.		27580.	18715.0		1210300
" " A6		265.5		1121.0		4130.		4130.	2802.5		19750
" " A7		1770.3		7474.6		27538.		27538.	18686.5		1287550
" " A8		1425.6		6019.2		22176.		22176.	15048.0		1029600
" " A9		545.4		7302.8		8484.		8484.	5757.0		393900
" " A10		1827.5		7715.9		28427.		28427.	19289.8		1319825
" " A11		261.0		1102.0		4060.		4060.	2755.0		126750
Sub-Total		11833.3		49962.4		184072.		184072.	124906.1		8406675
SURFACE WATER											
Athabasca River											19198.
Clearwater River											816.
Algar Lake											920.
Legend Lake											1725.
Namur Lake											4830.
Gardiner Lakes											6670.
Eaglenest Lake											920.
Gregoire Lake											3220.
McClelland Lake											3220.
Sub-Total											41519.
MOBILE SOURCES											
Roads and Highways	28.5		1272.47	168.7	2.93		2.93		519.1	14313.8	15.4
Aircraft	1.0		175.38	10.5					7.8	0.7	1.3
Railway	1.0		1.19	2.8	0.08		0.16		6.4	0.05	0.2
River Tugs	2.4		1.91	1.4	0.17				2.3	3.3	0.2
Sub-Total	32.9		1450.95	183.4	3.18		3.09		535.6	14317.8	17.1
VILLAGE SPACE HEATING EM.											
Fort McKay	0.8		0.52		0.07	0.5			2.2	5.8	0.4
Anzac	0.6		0.39		0.05	0.3			1.7	4.3	0.3
Sub-Total	1.4		0.91		0.12	0.8			3.9	10.1	0.7
FOREST FIRE EMISSIONS											
All Causes	0.9		289.29	96.4					9.6	81.8	5.5
GRAND TOTAL	35.2	11833.3	1741.15	50242.2	3.30	184073.	3.09	184072.	125455.2	14409.7	8448216.6

Table 5. Summary of emissions from all sources, 1976.

SOURCE OWNERSHIP	SO_2	H_2S	CO	LIGHT HC (AS CH_4)	RCHO (AS HCHO)	HEAVY ORGANICS	ORGANIC ACIDS	NH_3	NO_x (AS NO_2)	PARTI-CULATES	WATER VAPOR
	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^6 g$	$10^9 g$
NATURAL SOURCES											
Forests	1.09	11833.3	289.29	50058.8		184072.		184072.	124915.7	81.8	8406675.0
Surface Water											41519.
Sub-Total	1.09	11833.3	289.29	50058.8		184072.		184072.	124915.7	81.8	8448194.0
MOBILE SOURCES											
Roads and Highways	28.5		1272.47	168.7	2.93		2.93		519.1	14313.8	15.4
Aircraft	1.0		175.38	10.5					7.8	0.7	1.3
Railway	1.0		1.19	2.8	0.08		0.16		6.4	0.5	0.2
River Tugs	2.4		1.91	1.4	0.17				2.3	3.3	0.2
Sub-Total	32.9		1450.95	183.4	3.18		3.09		535.6	14317.8	17.1
TOWNS AND SETTLEMENTS											
Fort McMurray	35.1	23.0	1142.17	127.1	7.26	770.0	0.57	357.	1125.6	5113.1	16645.73
Fort McKay	0.8		0.52		0.07	0.5			2.2	5.8	0.4
Anzac	0.60		0.39		0.05	0.3			1.7	4.3	0.3
Sub-Total	36.5	23.0	1143.08	127.1	7.38	770.8	0.57	357.	1129.5	5123.2	16646.43
GREAT CANADIAN OIL SANDS	93036.06	13.0	1053.46	326.06	21.78	4633.33	0.12	203.	7368.41	15491.89	13252.68
SYNCRUDE CANADA	44.47	84.2	632.67	418.20	11.20	1309.00	0.18	1309.	1632.01	34.23	60787.19
IN SITU											
Amoco	110.00		9.30	5.71					159.87	44.35	24.27
Texaco	0.11		3.04	0.54					21.64	3.27	18.82
Petro-Canada	nil		nil	nil							
Sub-Total	110.11		12.34	6.25					181.51	47.62	43.09
GRAND TOTAL	93261.13	11953.5	4581.79	51119.81	43.54	190785.13	3.96	185941.	135762.73	36096.54	8538923.4

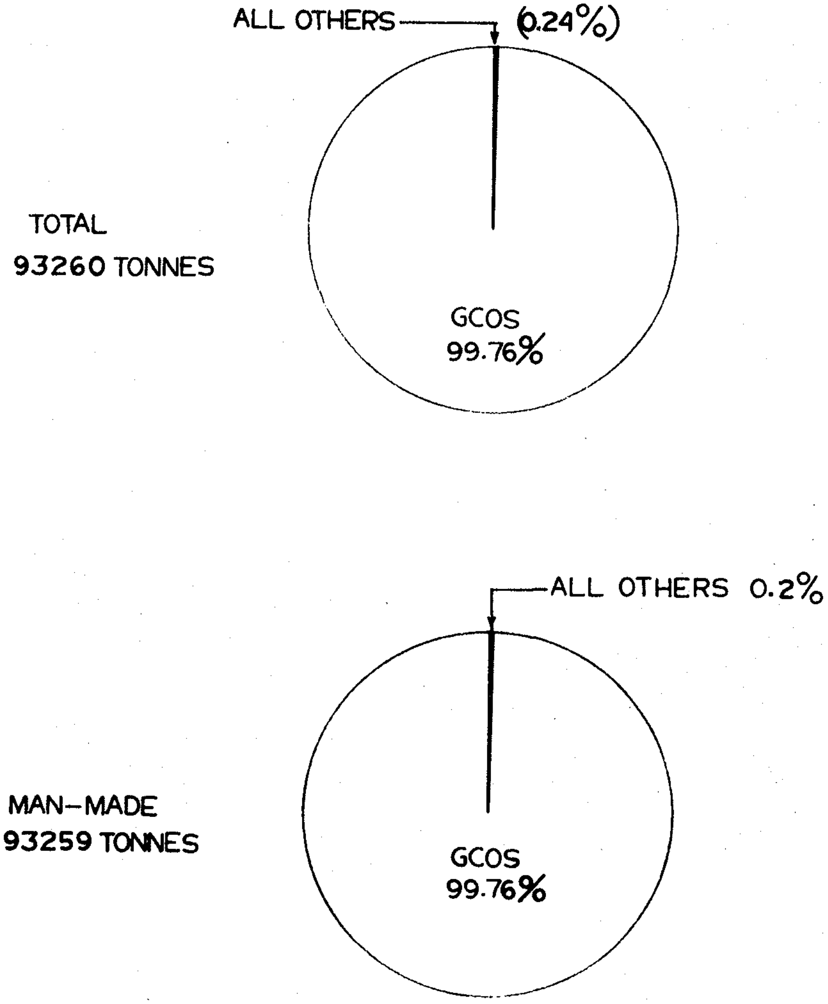


Figure 2. Sulphur dioxide emissions, 1976, breakdown by "ownership".

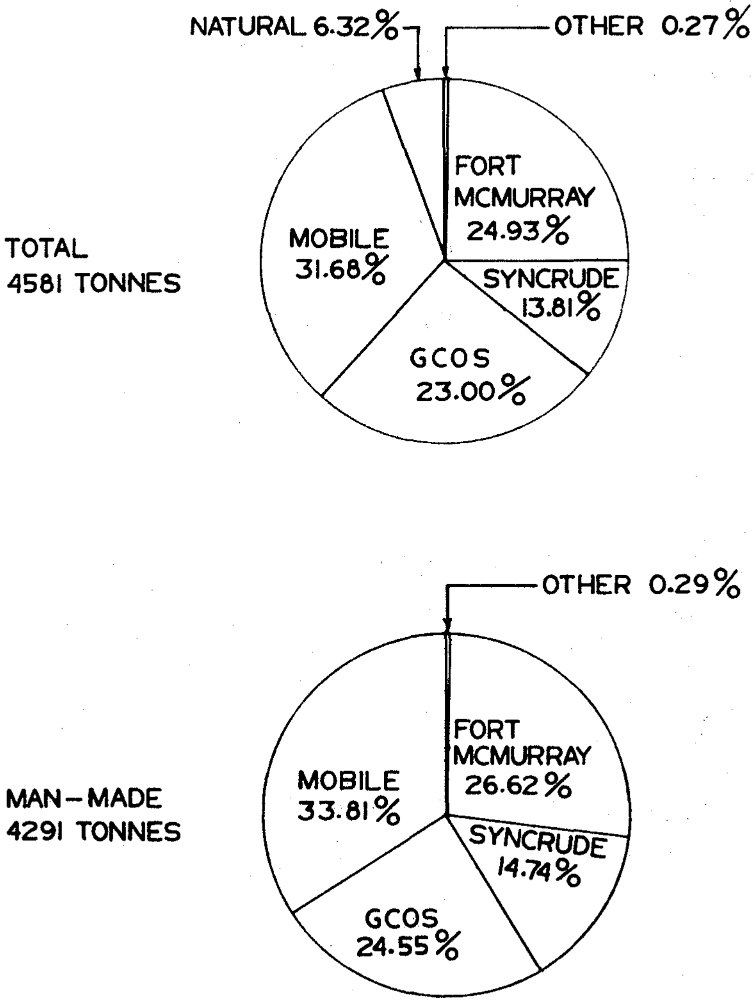


Figure 3. Carbon monoxide emissions, 1976, breakdown by "ownership".

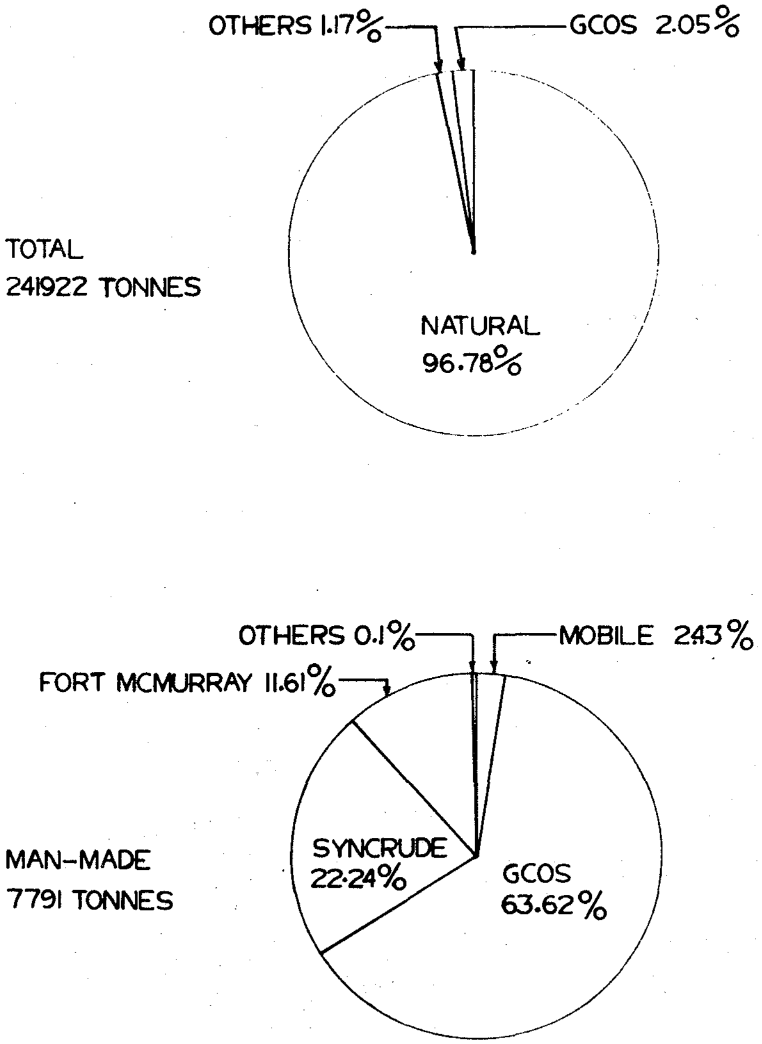


Figure 4. Total organics emissions, 1976, breakdown by "ownership".

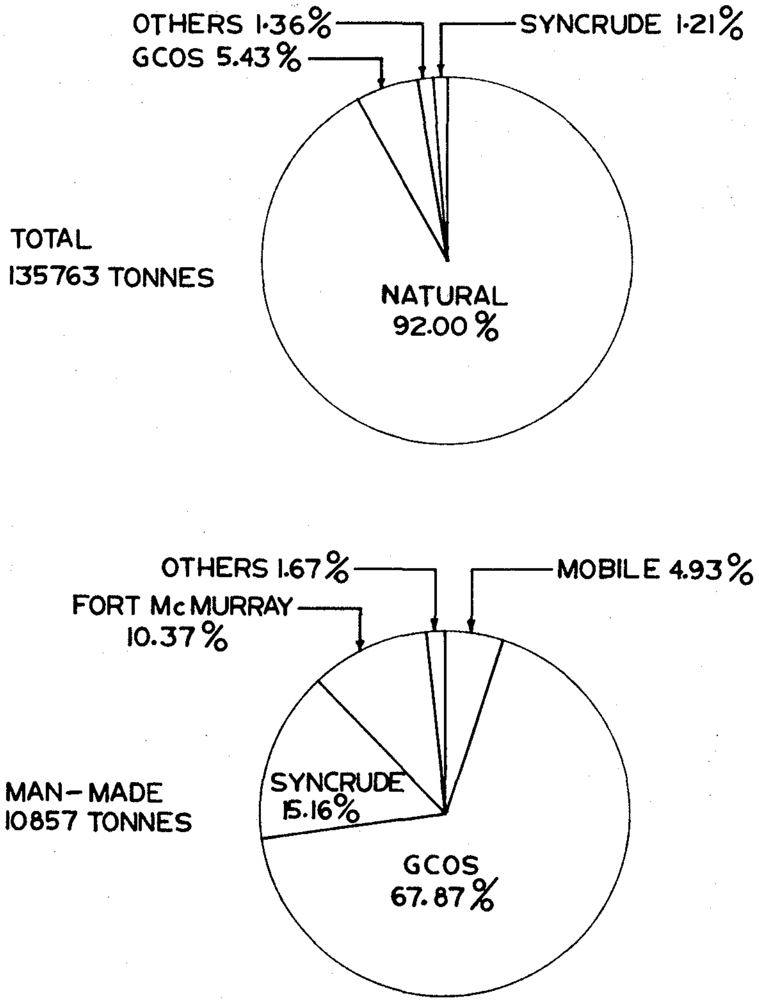
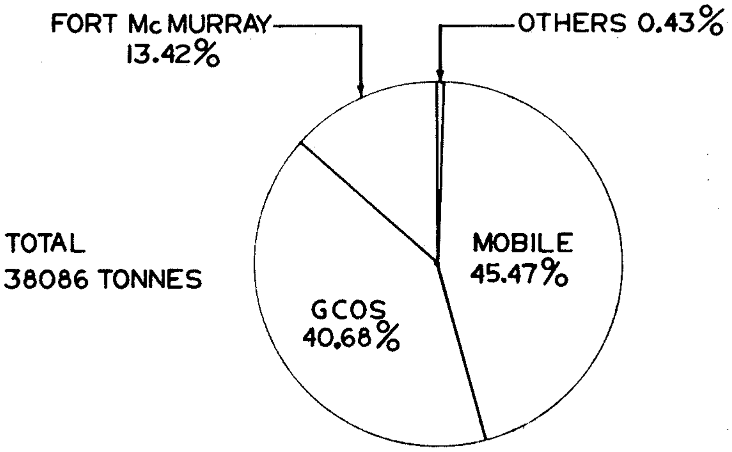


Figure 5. Oxides of nitrogen emissions, 1976, breakdown by "ownership".



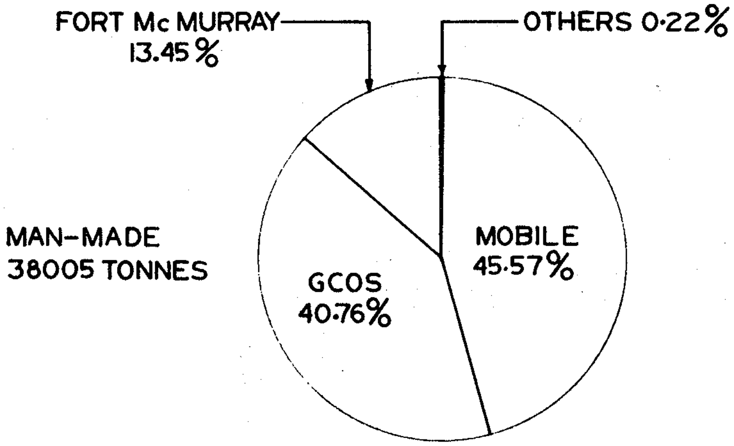
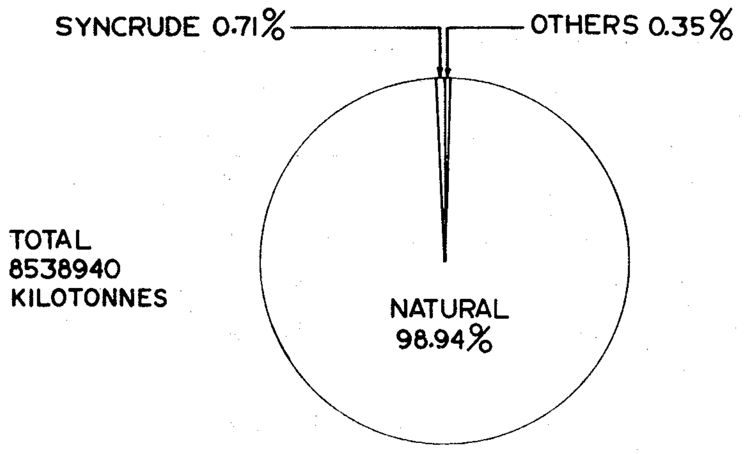


Figure 6. Particulate emissions, 1976, breakdown by "ownership".



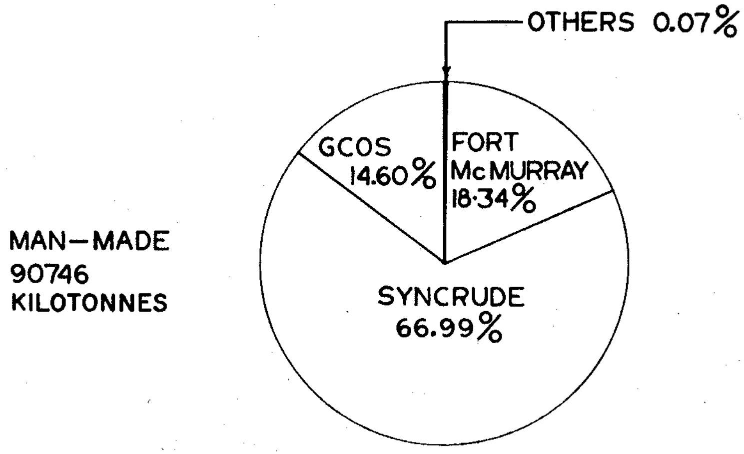


Figure 7. Water vapor emissions, 1976, breakdown by "ownership".

3. DATA STORAGE AND RETRIEVAL STYSTEM

The design of the computerized data storage and retrieval system received careful attention to ensure that the final system would be able to store, update, and report all information identified within the terms of reference. Without a precise definition of the specific needs of all the ultimate users, the data storage and reporting formats had to be generalized.

The system as designed provides the ability to add, change, delete, or report any individual item or group of data. It also allows the selection of data by year, geographical location, plant site, and source type, and will have the ability to pre-select the specific materials to be reported. A brief description of the system follows.

More detailed information regarding the use of and extraction of specific data from the retrieval system is available from Alberta Environment, Air Quality Control Branch.

3.1 INFORMATION RETAINED BY THE SYSTEM

The computerized data storage system is designed to retain data for each source relating to its location, ownership, key physical characteristics, expected temporal variations, and annual quantities emitted for each material identified. The data stored are divided into five categories for each source: identification, description, physical characteristics, temporal variations, and estimated emission amount by component. Each of the sections is described briefly below.

3.1.1 Source Identification

The source identification provides a unique label for each emission source. It includes the year to which the emission values apply, a description of the source location by the grid co-ordinates from the civilian grid system on the 6^{o} Universal Transverse Mercator (UTM) projection, a code identifying the source ownership and activity, and the general source type. The source identification is the key that provides access to specific information for any individual source.

Figure 8 shows the study area with the UTM grid overlay. It also shows the locations of the Syncrude and Great Canadian Oil Sands (GCOS) leases and the town of Fort McMurray.

3.1.2 Source Description

This section contains a brief description of the source to improve the readability of generated reports by giving a recognizable name of the source. Included in the description section is information about the method used to estimate the emission values, and a reference number to locate the calculations.

3.1.3 Physical Characteristics

The physical characteristics give data pertinent to the particular source type. The type of information stored differs for each source type. For three of the four source types, the stored data provide the basis for estimation of the emission values. For the fourth source type, (stationary man-made sources), the physical characteristics provide data on the size, elevation, emission temperature, and normal and maximum frequency of occurrence for the source.

3.1.4 Temporal Variation Parameters

The temporal variation parameters provide factors to modify the annual emission totals for seasonal variations, with additional factors to provide maximum monthly, daily, and instantaneous values for the emissions. The use of factors will allow modelling to be done on an average case/worst case basis.

3.1.5 Emission Values

All emission values are given in metric units. The annual total emission quantities will be estimated in mass units ranging (theoretically) from gigagrams (Gg; 10^9g) to milligrams (mg; 10^{-3}g). For major stationary man-made sources, a special code identifies the volumetric flow rate in volumetric units per second. The most usual units of volume are litres and cubic metres.

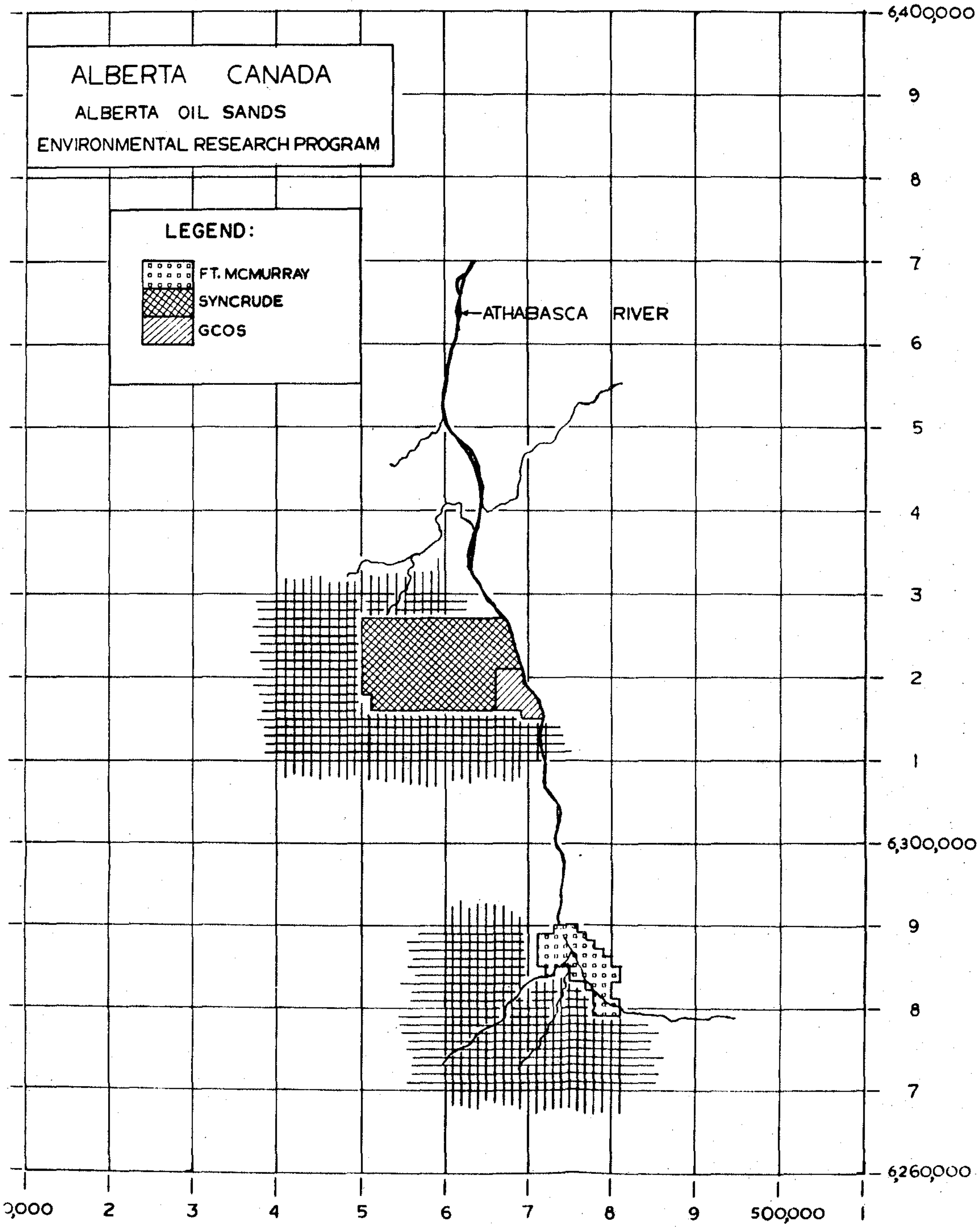


Figure 8. Project study area with UTM grid overlay.

3.2 SYSTEM INPUT AND UPDATING

All information can be put into the system using the Comprehensive Input Document. Several other forms are also provided for specialized purposes in updating where the changes are repetitious and affect only part of the source record. Samples of the various forms are included in Appendix 11.1.

The system is designed so that any or all information in each record can be altered except for the source identification. An error in the identification section can only be corrected by deleting the incorrectly identified record and adding the entire new, correct record.

The flexibility of the updating procedure is intentional to provide for convenient entry of data as improvements are made in estimating or measuring techniques.

3.3 REPORT GENERATION CAPABILITY

The system is designed to produced four basic reports. A brief description of each type follows:

1. List of Source Data. This report lists the information contained in the physical characteristics section of the source records. A separate report number is specified for each of the four general source types (stationary man-made, mobile, fugitive dusts, and natural sources).
2. List of Temporal Variations. This report lists the factors used to modify the annual emission values to provide seasonal averages or maximum monthly, daily, or instantaneous values.
3. List of Emission Data. This report provides a complete list of the information on file in the emission data section.
4. Summary of Emissions. This report facilitates the sorting of emission data and produces lists of emissions for each source with subtotals for pre-selected groups of sources. This report is expected to satisfy the needs of most of the users.

A multipurpose selection facility is available in the reporting procedure. Each one of the main report types can be extracted by any one or combination of the following items:

1. Year,
2. Geographical location,
3. Ownership/Activity code,
4. Source type, or
5. Emission.

A sample report selection form along with the resulting report is included in Appendix 11.2.

4. DETERMINATION OF EMISSION SOURCES

From a knowledge of the activities, both man-made and natural, occurring within the AOSERP study area, lists of potential sources were developed and organized into major groups according to ownership and/or other common characteristics. The sources were broken down into natural and man-made with a further breakdown of man-made sources into a number of sub-categories.

To determine the location of the sources, several methods were available. The use of maps at various scales allowed the definition of locations of roads, highways, settlements and developments for locating distributed sources such as mobile emissions, urban emission, and others occuring over larger areas. For the location of major point sources on the sites of the Syncrude and Great Canadian Oil Sands plants, plot and site plans were provided with a higher degree of detail. Calculation of UTM co-ordinates from plant grids was done by mathematical translation from a known reference point.

The accuracy of the location of any specific point in absolute terms varies depending upon the scale of the map used for locating the given source. Generally, the accuracy is as follows:

	Error (metres)	
Source Size	Worst	Most Likely
1 km x 1 km	500	100
100 m x 100 m	50	10
10 m x 10 m	10	5
1 m x 1 m	10	5

It should also be noted that for the Syncrude and GCOS plant sites, errors will be consistent since a rigorous calculation was used to locate the sources. Hence, while the source location may be in error in absolute terms, the location relative to the other sources within the two plant sites will be accurate to within five metres or less.

5. EMISSIONS OF POLLUTANTS

To make quantitative estimates of emissions for each source, one or more of the following methods was used. The methods are listed in order of decreasing accuracy:

1. Measured flow rate and chemical analysis of material emitted.
2. Design basis material balance.
3. Factored estimate from consumption of raw materials (i.e., gasoline, diesel fuel, or natural gas combustion).
4. Factored estimate from activity volume (i.e., traffic counts).
5. Factored estimate from processing rate (i.e., miscellaneous hydrocarbon emissions from refineries or fugitive dusts from gravel processing).
6. Proration of data from laboratory scale measurements (i.e., hydrocarbon emissions from oil sands reservoirs).
7. Calculation from physical properties of source material (i.e., surface water evaporation).
8. Proration of estimated global emissions (i.e., natural emissions of hydrogen sulphide, methane, and ammonia).

Accuracy for the various estimation methods varies from ± 10% for measured flow rates and anaylses to less than order of magnitude for proration of global estimates with the methods between numbers 1 and 8 on the list lying somewhere between the extremes.

6. PROJECTED EMISSIONS, 1976 THROUGH 1985

6.1 OVERALL DEVELOPMENT SCENARIO

Even with the limited time span of this study it is difficult to project how development will proceed in the study area over the 10 years 1976 through 1985. The many external factors to be considered include both provincial and federal government policies, regional, national, and international economics, and the mounting pressures from environmental groups and agencies. This list is far from exhaustive but is sufficient to show the causes for the very tenuous nature of any prediction.

In general terms, the 10-year span from 1976 through 1985 will probably be a period of maturation during which the main development will centre around refining methods currently being practiced and providing more amenities and services for the existing population.

Industrial development during the life of AOSERP will probably be limited to increased production at both Syncrude and Great Canadian Oil Sands plants to rates as much as 50 percent higher than the current permits authorize. The operation of a third surface mining oil sands plant is unlikely over the 10-year span in view of the uncertainty of the overall economics of such projects.

In situ operation will not likely progress beyond the pilot scale before the end of 1985. The planned development of Cold Lake and Lloydminister heavy oil, and the potential development of Peace River deposits almost precludes any large scale in situ operation in the Athabasca deposit before the end of the 1980's. It is possible that a number of new pilot plants could be under construction or in operation by the end of 1985. The projected emissions, however, include only those from plants either in operation at present or currently committed to be in operation before 1986.

Urban development through 1985 will remain centred around Fort McMurray, assuming that a third large scale project does not start during the intervening years. It is estimated that the population of Fort McMurray will reach 28,000 to 30,000 by the end of

1980 at which time Syncrude will be at design operating capacity. In the years 1981 through 1985 Fort McMurray should grow at an annual rate of something less than 10 percent as service industries and social amenities develop in the maturing small city.

Figures 9 to 14 present the projected quantities of emissions from all man-made sources of the six most prevalent materials that man contributes to the atmosphere. A capsule comment on each chart is included to highlight the significance of the trends.

6.2 PROJECTED SULPHUR DIOXIDE EMISSIONS

Not surprisingly, the major sources of SO_2 emissions will continue to be the Great Canadian Oil Sands and Syncrude Canada plants. Note that Figure 9 shows a slight maximum in 1981. The maximum is suggested since it is anticipated that the early years of operation at Syncrude will experience a higher frequency of operating problems leading to slightly higher total SO_2 emissions. This comment applies as well to the projected emissions of most other materials from Syncrude.

The projected sulphur dioxide emissions from Great Canadian Oil Sands do not reflect the effect of possible modifications which may be made as early as 1979 to reduce emissions from the power plant stack.

6.3 PROJECTED CARBON MONOXIDE EMISSIONS

A major source of carbon monoxide emissions is the burning of wood refuse from either land clearing or saw mill operations. To formulate the projected emissions of carbon monoxide required the estimation of mining development at both GCOS and Syncrude. The contribution from the lumbering industry was held constant at the low 1976 level and will be influenced largely by the general demand for lumber over the next few years.

The development plant for GCOS assumed that approximately 101 to 122 ha (250 to 300 acres) of land would be cleared on the average every second year. Syncrude's intention was to wait until 1983 to strip the area required for the future mining. The quantity to be cleared will be sufficient for at least five years mining.

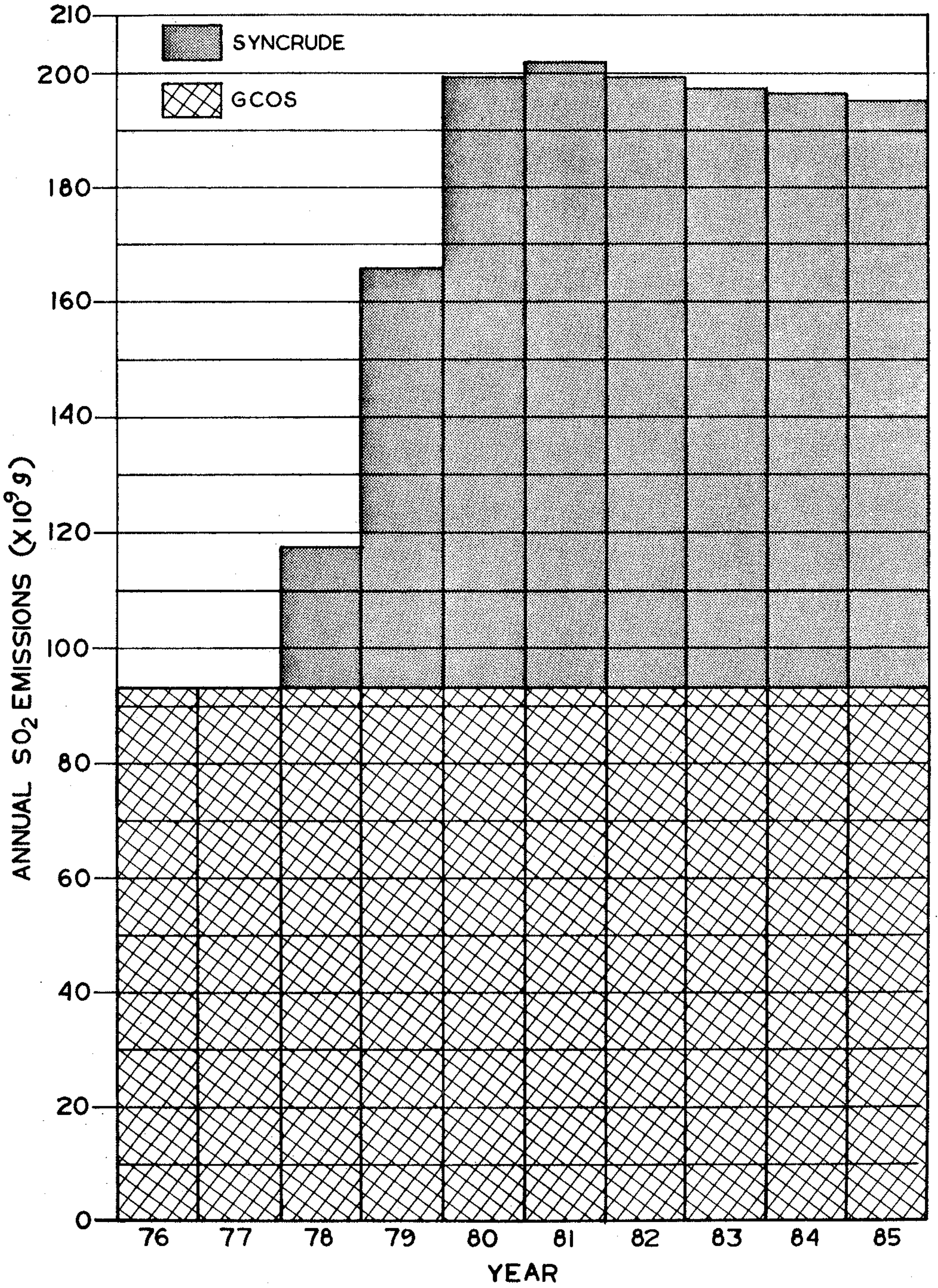


Figure 9. Projected SO_2 emissions - man made sources.

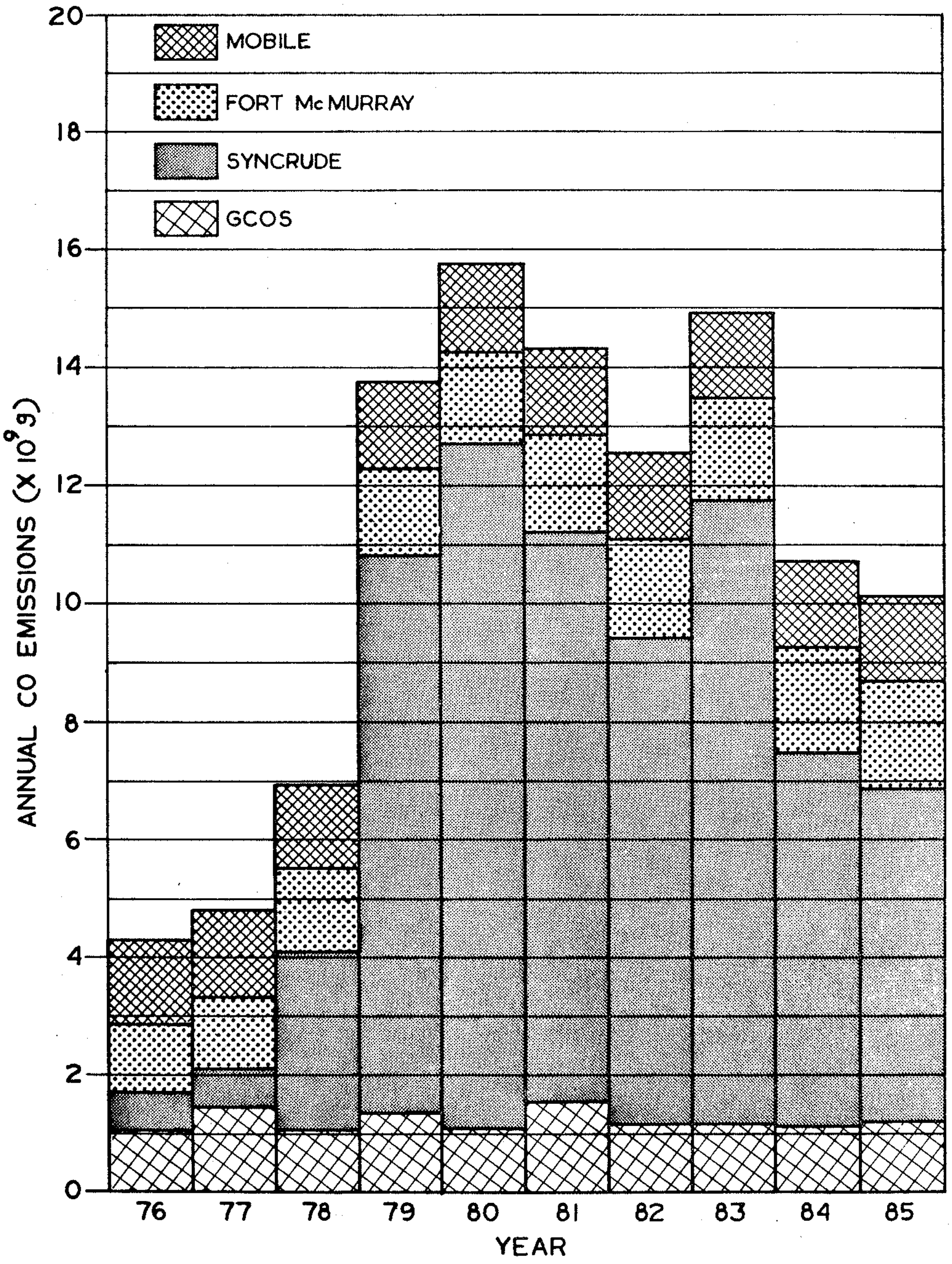


Figure 10. Projected CO emissions - man made sources.

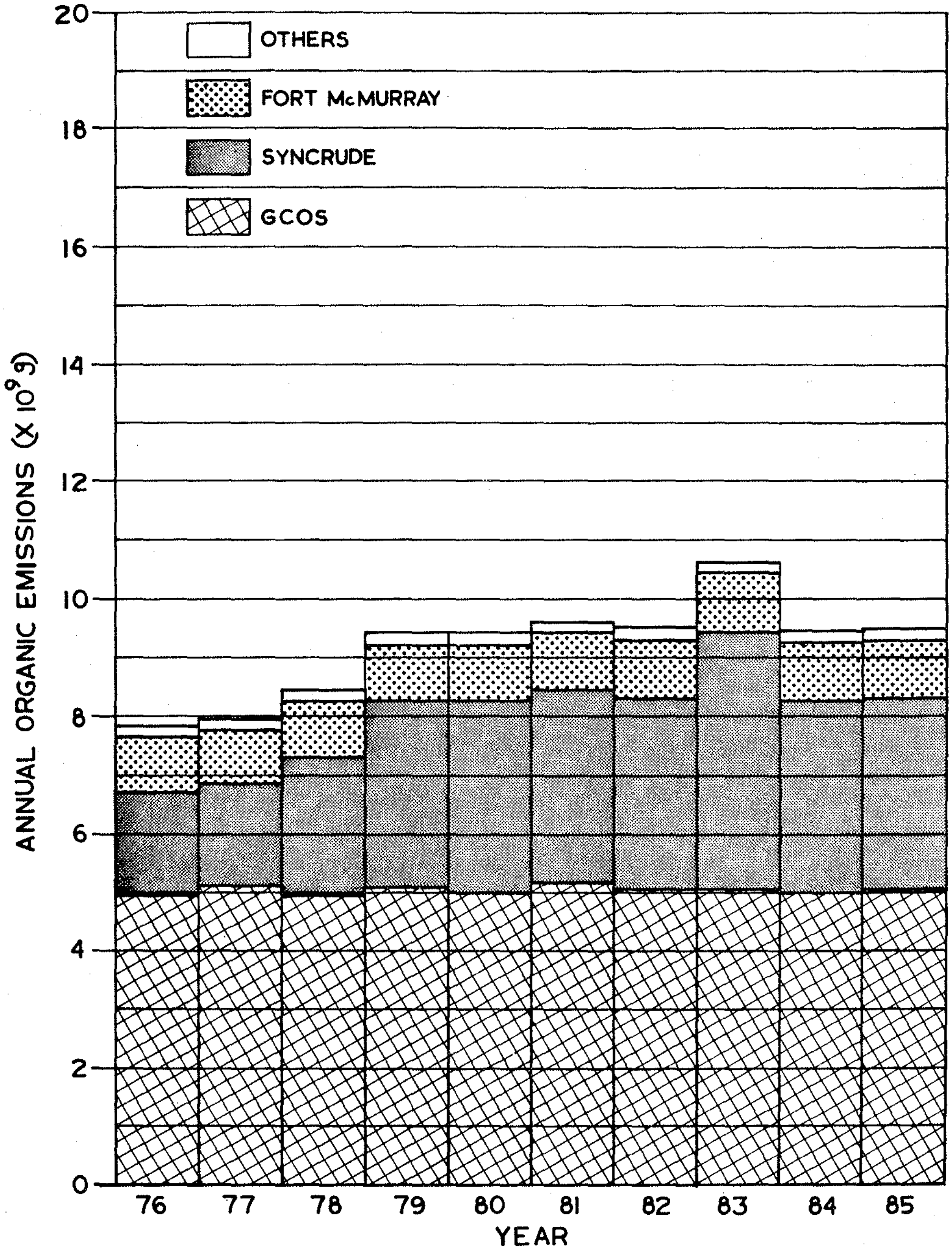


Figure 11. Projected total organic emissions - man made sources.

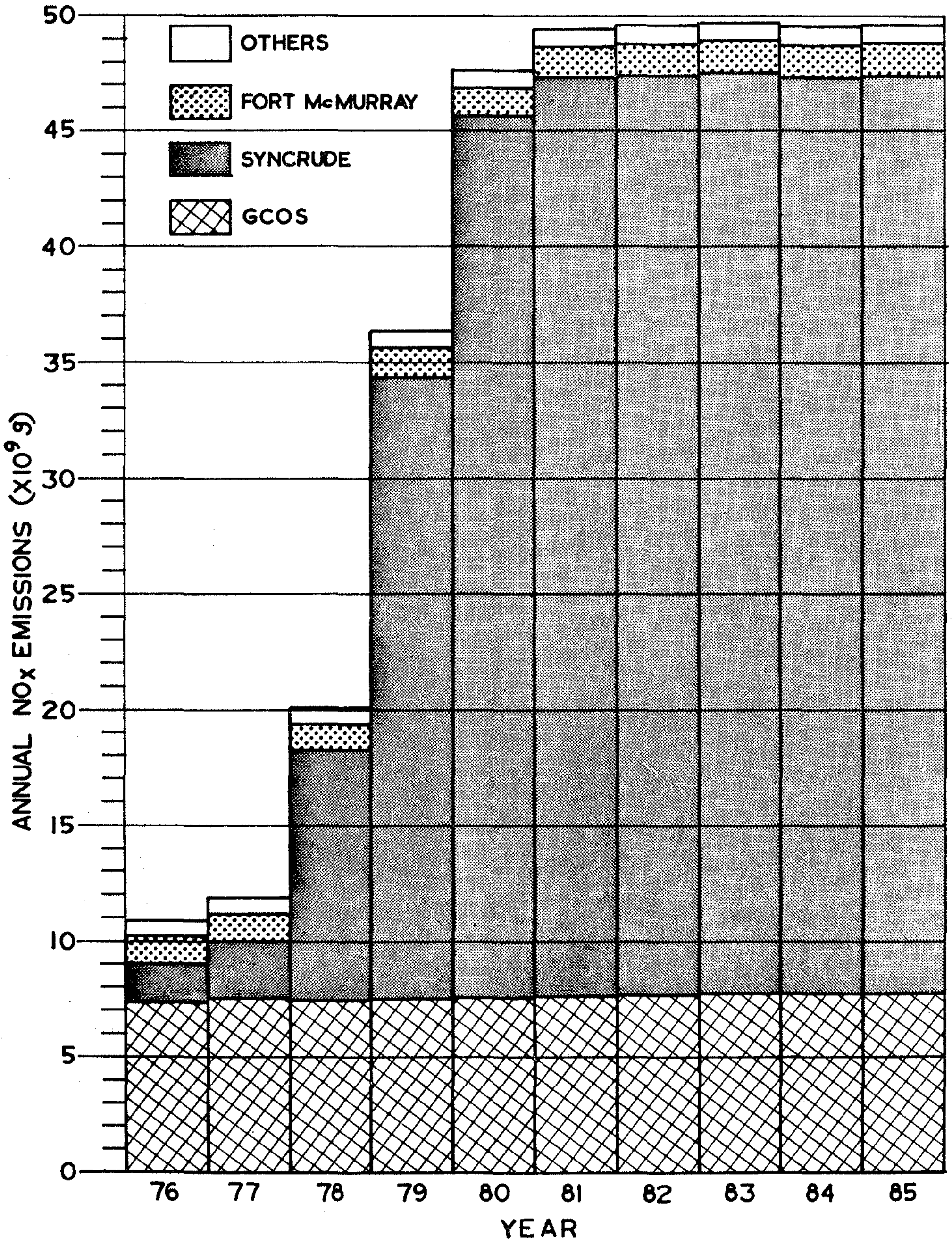


Figure 12. Projected NO_x emissions - man made sources.

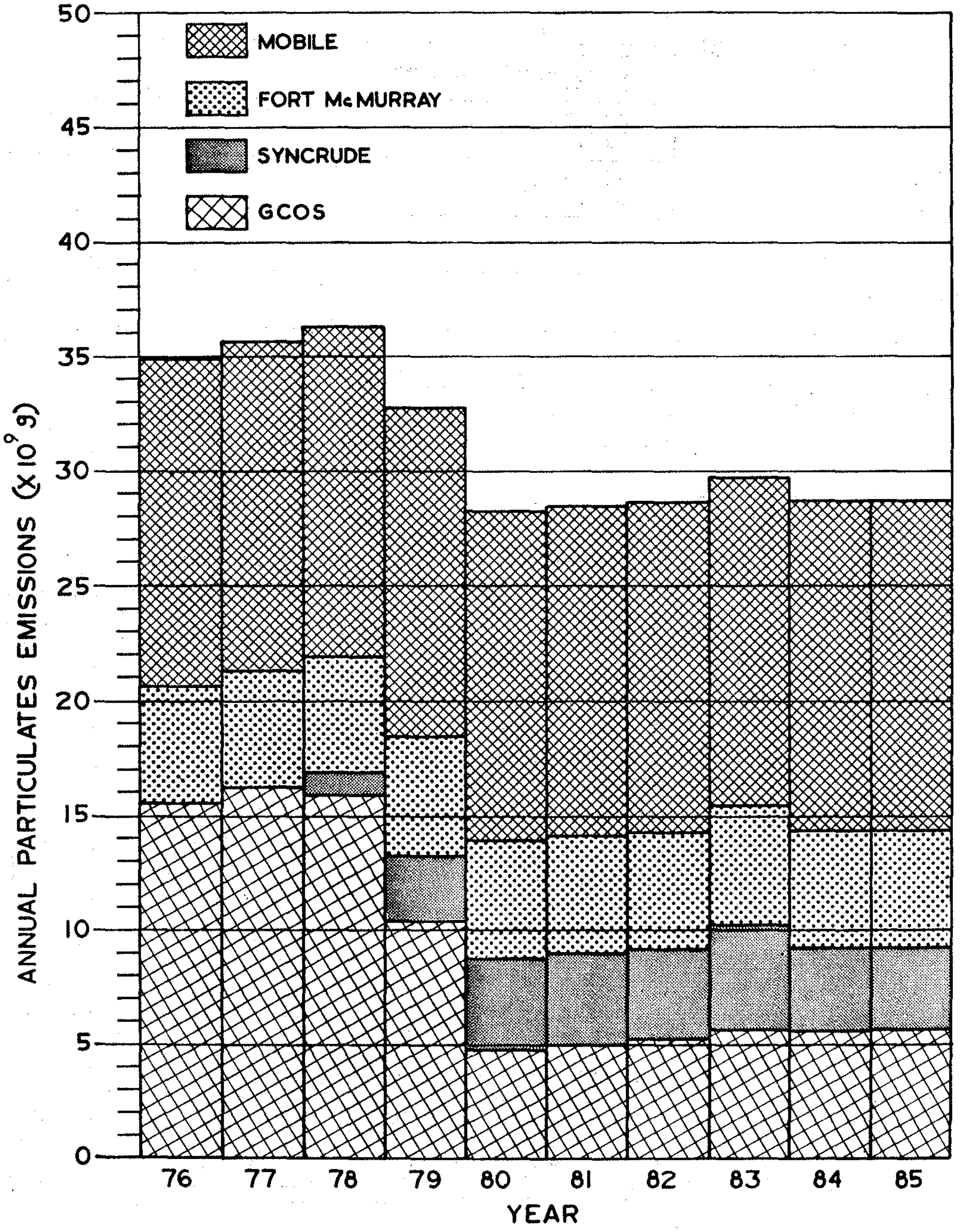


Figure 13. Projected particulate emissions - man made sources.

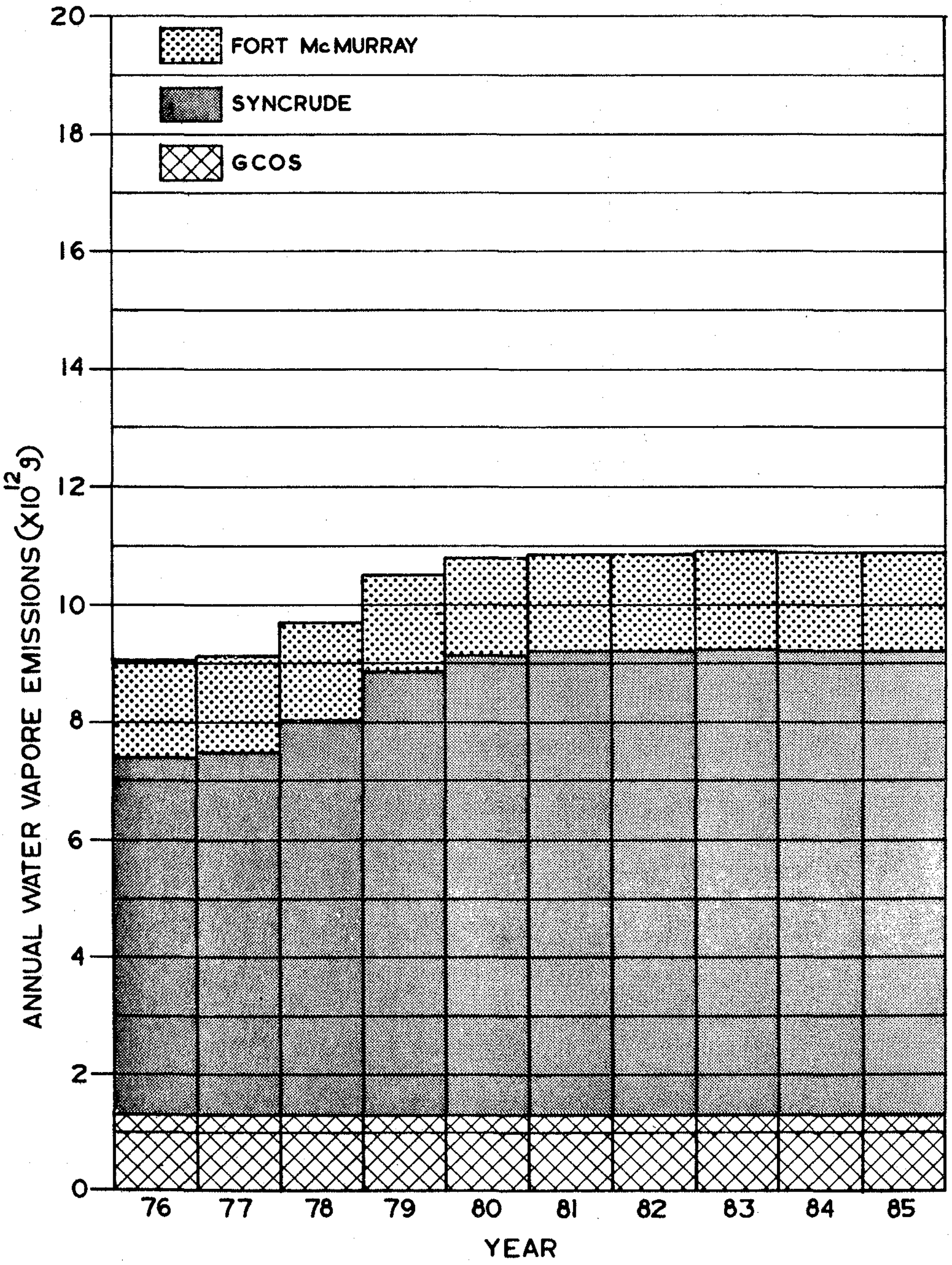


Figure 14. Projected water vapor emissions - man made sources.

Another significant source of carbon monoxide from Syncrude's plant are the emergency bypass stacks upstream of the CO boilers. These stacks are designed to vent gas from the fluid cokers while they are being shut down after an unscheduled shutdown of the CO boilers. It is possible that the material emitted to the stack will ignite spontaneously when it comes in contact with the air, in which case the carbon monoxide will burn to the dioxide form.

6.4 PROJECTED EMISSIONS OF ORGANIC MATERIALS

The projected dominance of GCOS in organic emission is largely accounted for by the fact that there is no attempt to recover hydrocarbons from storage tank vents throughout their process. In addition, surface evaporation of hydrocarbons from tailings and waste water ponds contributes significantly to the total organic emissions.

6.5 PROJECTED EMISSIONS OF OXIDES OF NITROGEN

The major man-made sources of nitrogen oxides are internal and external combustion processes. Since these sources are generally associated with normal operation (as opposed to unusual or upset conditions) the total emissions tend to increase as Syncrude's production increases and as the general level of activity and population in the area increases. Figure 12 reflects the continuous growth of NO emissions.

6.6 PROJECTED PARTICULATE EMISSIONS

Current particulate emissions are attributed to two major sources within the area. The first is road dusts caused by vehicles travelling gravel roads, and the second is GCOS.

Particulate emissions from gravel roads are held constant to reflect the compensating tendencies of paving existing roads with increased traffic volume and increased number of gravel surfaced access roads.

Great Canadian Oil Sands particulate emissions are reduced in 1979 and on to reflect modifications planned for the power plant stack to meet 1979 Clean Air Act licence requirements.

6.7 PROJECTED WATER VAPOR EMISSIONS

Water vapor emissions from man made causes have two major source categories. They are combustion of hydrogen containing fuels and evaporation from cooling towers, ponds, lagoons, and open reservoirs.

Emissions from water surfaces will be affected primarily by climatic conditions. The combustion related emissions show an increasing tendency as the level of activity increases.

Water vapor emissions for GCOS agree quite well with those estimated by Stanley and Associates (Croft et al. 1977). Estimates for Syncrude emissions are lower in this report due primarily to revised estimates of annual cooling tower emissions.

7. FORMS, ASSOCIATIONS, AND COMPLEXES OF SUBSTANCES EMITTED TO THE ATMOSPHERE

The man-made sources which contribute the largest quantities of pollutants to the atmosphere are the major process and utility stacks on the GCOS and Syncrude plant sites. The types of materials emitted depend upon many factors such as fuel burned, combustion conditions, fire box temperature, flame retention time, and flue gas temperature.

The materials emitted from the major sources are discussed below in sections dealing separately with sulphur, nitrogen, organics, and particulates.

7.1 SULPHUR COMPOUNDS

In the types of furnaces employed in normal refinery processes and utility production, sulphur present in the fuel is burned predominantly to sulphur dioxide. Depending upon the type of fuel and the method of firing, one to two percent of the sulphur will convert to the trioxide form. Since the trioxide form accounts for only a small percentage of the total and since a reliable method of estimating the trioxide formed was not available for most of the fuel types and combustion conditions, all sulphur emissions were identified and coded as equivalent sulphur dioxide. To estimate the amount of trioxide emitted from furnaces and incinerators, assume one percent of the sulphur dioxide is actually trioxide.

Other forms in which sulphur can and does enter the atmosphere are those of elemental sulphur and/or metallic sulphides. These forms are present in the particulate matter emitted from the boiler plant stacks of Great Canadian Oil Sands. In terms of the total sulphur emission from the stack, however, the sulphur/sulphides account for less than one percent of the total sulphur emission under the conditions of maximum particulate emissions.

7.2 NITROGEN COMPOUNDS

The two major nitrogen compounds formed in furnaces and incinerators are nitric oxide (NO) and nitrogen dioxide (NO_2). The total amount formed as well as the relative proportions of each material are influenced by a number of conditions within the furnace and flue, including fuel properties, combustion temperature, gas retention time, and flue gas temperature. A combination of higher combustion temperatures, increased residence times, and higher excess oxygen contributes to an increase in the production of oxides of nitrogen; while nitric oxide is unstable at ambient temperatures, the reaction rate is so slow that the material persists for long periods after the temperature is reduced.

Only a small amount of NO is converted to NO_2, and, in general, the predominant form of the emission is nitric oxide.

Emission factors published in literature invariably estimate oxides of nitrogen in the equivalent of the dioxide form. Thus all values included in the inventory are quoted as equivalent NO_2. It must be noted that while all values are quoted as nitrogen dioxide, the actual quantity of the dioxide species likely will be only one to ten percent of the total.

7.3 ORGANICS

Associated with the combustion of liquid and gaseous fuels and to a lesser extent solid fuels varying quantities of hydrocarbons are emitted with the combustion product. The development of high efficiency burners and improved furnace design has reduced significantly the quantities of hydrocarbons emitted. Still, however, small quantities of light hydrocarbons are contained in the flue gas from nearly all furnaces and certainly all internal combustion sources.

The significant contribution of hydrocarbon emissions is the part they play in the formation of secondary particulate and aerosols.

7.4 PARTICULATES

Particulates released from furnace and incinerator stacks are classified as either primary or secondary. The distinction between the two is as follows. Primary particulates are derived from solid, inorganic material contained in the fuel which is either unchanged or only slightly altered by the combustion process. Secondary particulates are those precipitated by the reaction of materials in the flue gas with free radicals, condensation nuclei, or natural catalysts. A discussion of the nature of each type of particulates is given below.

7.4.1 Primary Particulates

As stated above, primary particulates result from ash materials (non combustibles) contained in the fuels. The major source of primary particulates from Great Canadian Oil Sands is in the form of fly ash from the power plant stack. Analysis of the fly ash showed the major components to be unburned carbon, silica and alumina. In addition, many metals were present in measurable quantities including, nickel, titanium, iron, calcium, magnesium, potassium, sodium, molybdenum, chromium, zinc, strontium, manganese, lead, copper, cobalt, arsenic, and mercury. Additional non metallic elements present were sulphur and phosphorous. The metals are emitted almost entirely in stable oxide forms. A small amount may be emitted as sulphides. Analysis of three samples of fly ash is presented in section 8, along with a discussion of the data.

7.4.2 Secondary Particulates

Secondary particulates are formed generally by reaction of materials in the flue with the reactions promoted by condensation nuclei which may be high energy free radicals or aeorsols of hydrocarbons or sulphates. The secondary particulate emissions are relatively small for the most heavily used fuels within the study area. For the purposes of the inventory, primary and secondary particulates are not differentiated. However, since there are, or will be, only two sources of primary particulates (the main stacks of Great Canadian Oil Sands and Syncrude) all other combustion sources showing particulates are assumed to be secondary.

8. ANALYSIS OF FLY ASH SAMPLES FROM GCOS

Three samples of fly ash from the GCOS power plant stacks were obtained for analysis by an independent laboratory. The analyses requested covered every element believed to be present.

The samples were provided from material collected during the testing of an electrostatic precipitator in November and December 1975. Although the material was stored in water tight drums, the one year lapse between the time the material was collected and the samples were presented for analysis undoubtedly allowed for some changes in the composition of the fly ash.

The analytical methods are described in Table 6. The method number is used in Table 7 to identify the method employed in the determination of the different elements.

Table 7 presents the analytical results as reported by the laboratory. In every case except silica, the material is reported as the amount of the element. Silica is reported as SiO_2. The units, as noted on the table, are dry basis weight percent unless noted otherwise.

Table 6. Analytical procedures employed for fly ash analyses.

Method No.	Description
1	Carbon was converted to CO_2 in a combustion furnace, absorbed as CO_2, and calculated as carbon.
2	Fusion with Na_2CO_3 and Na_2O_2, leached with water, precipitated as $BaSO_4$, and calculated as sulphur.
3	Fusion, leached with water, arsene evolved and colormetrically determined.
4	Fusion, leached, acidified, and determined by atomic absorption.
5	Digestion with acid and determined by atomic absorption.
6	Fusion, leached out, and determined by atomic absorption.
7	Fusion, leached out, and determined colormetrically.
8	Acid digestion, separated, and determined colormetrically.
9	Fusion, leached out, separated, and determined colormetrically.
10	Determined by the Emission Spectrograph on the pulverized sample.
11	Acid digestion, solvent-extraction, and determined colormetrically.
12	Acid digestion, liberation of mercury, and determination by mercury analyzer.

Table 7. Analytical results of GCOS fly ash samples, Wt. % as element (or as noted).

Material	Method	Sample[a] 1	2	3
Carbon	1	11.26	10.29	20.73
Nickel	5	0.989	1.066	0.939
Vanadium	9	2.400	2.800	2.440
Titanium	8	1.936	1.846	1.336
Iron	5	4.60	4.49	4.75
Aluminum	5	11.20	11.35	12.29
Silica (SiO_2)	7	34.61	36.29	31.94
Chromium	5	0.018	0.019	0.017
Zinc	5	0.021	0.021	0.077
Strontium	5	0.036	0.038	0.030
Calcium	5	2.230	2.237	1.387
Manganese	5	0.090	0.084	0.095
Magnesium	5	0.837	0.850	0.712
Sulphur	2	1.48	1.60	1.59
Lead	5	0.026	0.026	0.025
Beryllium	5	N/D[1]	N/D[1]	N/D[1]
Copper	5	0.036	0.046	0.033
Molybdenum	4	0.242	0.252	0.210
Cobalt	5	0.020	0.019	0.017
Arsenic	3	8 ppm	10 ppm	3 ppm
Uranium	11	N/D[1]	N/D[1]	N/D[1]
Cadmium	5	N/D[2]	N/D[2]	N/D[2]
Phosphorous	8	0.118	0.126	0.052
Mercury	12	8 ppb	6 ppb	8 ppb
Zirconium	6	N/D[3]	N/D[3]	N/D[3]
Hafnium	10	N/D[3]	N/D[3]	N/D[3]

[a] Symbols: N/D = not detected: - [1] lower detection limit 10 ppm
- [2] lower detection limit 2 ppm
- [3] lower detection limit 1 ppm

9. RECOMMENDED FUTURE WORK

1. A program of periodic information requests to major operators in the study area should be initiated in the very near future. The purpose of the information request would be to update the data files, ensuring that the data are current and accurate. The minimum frequency for such requests is once per year.
2. A standard procedure should be implemented that would allow the transmission of all pertinent information on any permits or licences granted by Alberta Environment under the Clean Air Act for development within the study area. This information would serve as the basis to initialize source files for all new operations or correct data pertaining to existing sources.
3. As already discussed, the estimated emissions from natural sources are extremely tenuous. For a more meaningful determination of true "baseline" values, we would recommend that an intensive field study be undertaken to improve the accuracy of natural emission quantities. Such work was considered beyond the scope of this project.
4. An evaluation of current stack sampling procedures did not lead to any significant recommendation for change. However, the following potential problem is identified and duly noted. Present sampling procedures may develop a bias in the determination of volatile metallic compounds contained in stack gases, such as vanadium and titanium. We recommend that an investigation of the effect of sampling techniques on volatile metallic compounds be considered.

10. REFERENCES CITED

References are listed according to the section of the report to which they apply. Citations do not appear in each section within the report since references either deal with many specific aspects contained in the section or provide general background information.

5. EMISSIONS OF POLLUTANTS

Environmental Protection Agency. 1973. Compilation of air pollutant emission factors (2nd edition). Research Triangle Park, North Carolina. various sections.

Rasmussen, R.A. 1972. What do the hydrocarbons from trees contribute to air pollution? Jour. Air Poll. Contr. Assoc. 22(7): 537-543.

Rasmussen, R.A. and F.W. Went. 1964. Volatile organic matter of plant origin in the atmosphere. Science (5):566.

Roffman, A., and L.D. Van Vleck. 1974. The state-of-the-art of measuring and predicting cooling tower drift and it's deposition. Jour. Air Poll. Contr. Assoc. 24(9):855-859.

6. PROJECTED EMISSIONS, 1976 THROUGH 1985

Syncrude Canada Ltd. 1976. Site development and reclamation plan. Edmonton, Alberta. various sections.

Tost, D. 1976. Syncrude vows environmental responsibility. Hydrocarbon Processing. 55(10):102-106.

7. FORMS, ASSOCIATIONS, AND COMPLEXES OF SUBSTANCES EMITTED TO THE ATMOSPHERE.

Blakeslee, C.E., and H.E. Burbach. 1973. Controlling NO_x emissions from stream generators. Jour. Air Poll. Contr. Assoc. 23(1):37-42.

Burchard, J.K. 1974. The significance of particulate emissions. Jour. Air Poll. Contr. Assoc. 24(12):1141-1142.

______________ 1975. Significance of particulate emissions. Jour. Air Poll. Contr. Assoc. 25(2):99-100.

Chiou-Shuang, J.Y. 1976. Evaluating environmental impacts of stack gas desulforization processes. Env. Sci. and Tech. 10(1):54-58.

Crecelius, E.A., M.H. Bothner, and R. Carpenter. 1975. Geo chemistries of arsenic, antimony, mercury, and related elements in sediments of Puget Sound. Env. Sci. and Tech. 9(4):325-333.

Croft, B.R., A. Lamb, and R.N. Dawson. 1977. Preliminary investigation into the magnitude of fog occurrence and associated problems in the oil sands area. Prep. for Alberta Oil Sands Environmental Research Program by Stanley Associates Engineering Ltd. AOSERP Report 9. 87 pp.

Dochinger, L.S., and T.A. Seliga. 1975. Acid precipitation and the forest ecosystem. Jour. Air Poll. Contr. Assoc. 25(11):1103-1105.

Duce, R.A., and G.L. Hoffman. 1976. Atmospheric vanadium transport to the ocean. Atmospheric Environment 10:989-996.

Engdahl, R.B. 1973. A critical review of regulations for the control of sulphur dioxide emissions. Jour. Air Poll. Contr. Assoc. 23(5):364-375.

Feldstein, M. 1974. A critical review of regulations for the control of hydrocarbon emissions from stationary sources. Jour. Air Poll. Contr. Assoc. 24(5):469-478.

Fennelly, P.F. 1976. Primary and secondary particulates as pollutants. Jour. Air Poll. Contr. Assoc. 25(7):697-704.

Franz, G.J., and G.J. Kupchik. 1976. Solid waste, air pollution and health. Jour. Air Poll. Contr. Assoc. 26(2):116-118.

Goldstein, H.L., and C.W. Siegmund. 1976. Influence of heavy fuel oil composition and boiler combustion conditions on particulate emissions. Env. Sci. and Tech. 10(12):1109-1114.

Harrington, R.E. 1974. Fine particulates - the misunderstood air pollutant. Jour. Air Poll. Contr. Assoc. 24(10):927-929.

Hemeon, W.C.L. 1973. A critical review of regulations for the control of particulate emissions. Jour. Air. Poll. Contr. Assoc. 23(5):376-387.

Lee, R.E., Jr., and D.J. Von Lehmden. 1973. Trace metal pollution in the environment. Jour. Air Poll. Contr. Assoc. 23(10):853-857.

Likens, G.E. 1976. Acid precipitation. Chemical and Eng. News. November 22:29-44.

Linzon, S.N., et al. 1976. Lead contamination of urban soils and vegetation by emissions from secondary lead industries. Jour. Air Poll. Contr. Assoc. 26(7):650-654.

Moore, H. 1976. Discussion of article "The organic constituents of atmospheric particulate matter" by Junge et al. Geochimica Cosmochimica Acta:1037-1039.

Sheppard, J.C., and W.H. Funk. 1975. Trees and environmental sensors monitoring long-term heavy metal contamination of Spokane River, Idaho. Env. Sci. and Tech. 9(7):638-642.

Tullar, I.V., and I.H. Suffet. 1975. The fate of vanadium in an urban air shed: the Lower Delaware River Valley. Jour. Air Poll. Contr. Assoc. 25(3):282-286.

Williams, J.R., and C.G. Justus. 1974. Evaluation of nationwide health costs of air pollution and cigarette smoking. Jour. Air Poll. Contr. Assoc. 24(11):1063-1066.

11. APPENDICES

11.1 SAMPLE INPUT DOCUMENTS

OIL SANDS SOURCE EMISSION INVENTORY

COMPREHENSIVE INPUT DOCUMENT

1

YEAR		AREA CODE E		AREA CODE N		LOCATION CODE E		LOCATION CODE N		EXPANSION E	EXPANSION N	OWNERSHIP/ ACTIVITY CODE		SOURCE TYPE			
1		3	5	6	8	9	11	12	14	15	16	17	19	20			

2

D	DESCRIPTION OF SOURCE							DATA SOURCES					
21	22	25	30	35	40	45	51	52	55	60	65	70	

3

NOTE

CODE ONLY ONE OF TYPES S M N OR F

STATIONARY MAN MADE SOURCE DATA

S	DIAMETER		HEIGHT	GROUND ELEVATION	TEMPERATURE	NORMAL OCCURENCE FREQUENCY	NORMAL OCCURENCE DURATION	UNITS	MAXIMUM OCCURENCE FREQUENCY	MAXIMUM OCCURENCE DURATION	UNITS
21	22	25	28	34	40	44	47	50	51	54	57

MOBILE SOURCE DATA

M	TRAFFIC VOLUME	T	MEAN SPEED	MEAN DISTANCE	VEHICLE CATEGORY BREAKDOWN ONE	TWO	THREE	FOUR	VEHICLE-KM PER DAY	ENGINE SIZE AND TYPE OR FUEL CONSUMPTION			OPERATING HOURS PER YEAR	
21	22	26	27	30	34	37	40	43	46	51	55	60	64	

NATURAL SOURCE DATA

N	CONIFEROUS	DECIDUOUS	BUSH	MUSKEG	MARSH	OPEN WATER	BARE SOIL	OTHER
21	22	28	34	40	46	52	58	64

FUGITIVE DUST SOURCE DATA

F	SILT FRACTION	PRECIP. INDEX	NUMBER OF SOURCES	AVERAGE VELOCITY
21	22	26	29	32

4

TEMPORAL VARIATION PARAMETERS

Y	WINTER	SPRING	SUMMER	FALL	MAXIMUM MONTHLY	MAXIMUM DAILY	MAXIMUM INSTANTANEOUS	CONTROL DEVICE	EFFICIENCY
21	22	28	34	40	46	52	58	64	65

5

EMISSION DATA

	CODE	QUANTITY	M	CODE	QUANTITY	M	CODE	QUANTITY	M	CODE	QUANTITY	M	CODE	QUANTITY	M
X															
21	22	24	30	31	33	39	40	42	48	49	51	57	58	60	66
X															
21	22	24	30	31	33	39	40	42	48	49	51	57	58	60	66
X															
21	22	24	30	31	33	39	40	42	48	49	51	57	58	60	66
X															
21	22	24	30	31	33	39	40	42	48	49	51	57	58	60	66

OIL SANDS SOURCE EMISSION INVENTORY

SOURCE RECORD DELETE FORM

YEAR	AREA CODE		LOCATION CODE		EXP. CODE	OWNER-SHIP ACT. CODE	SOURCE	CARD	YEAR	AREA CODE		LOCATION CODE		EXP. CODE	OWNER-SHIP ACT. CODE	SOURCE	CARD	YEAR	AREA CODE		LOCATION CODE		EXP. CODE	OWNER-SHIP ACT. CODE	SOURCE	CARD
1	E 3	N 6	E 9	N 12	E N 15	17	20	21	1	E 3	N 6	E 9	N 12	E N 15	17	20	21	1	E 3	N 6	E 9	N 12	E N 15	17	20	21
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A
								A									A									A

OIL SAND SOURCE EMISSION INVENTORY

SOURCE DESCRIPTION UPDATE FORM

YEAR	AREA CODE		LOCATION CODE		EXP. CODE	OWN. SHP. ACT. CODE	SOURCE	CARD	DESCRIPTION	DATA SOURCES
1	E 3	N 6	E 9	N 12	E N 15	17	20	21	22 25 30 35 40 45 50	52 55 60 65 70 72
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		
								D		

OIL SANDS SOURCE EMISSION INVENTORY

STATIONARY MAN MADE SOURCE DATA UPDATE FORM

YR.	AREA CODE		LOCATION CODE		EXP. CODE	OWN./ ACT. CODE	S T.	T Y P.	DIAMETER	HEIGHT	GROUND ELEVATION	EMISSION TEMP.	NORMAL OCCURRENCE			MAXIMUM OCCURRENCE		
	E	N	E	N	EN								FREQ.	DUR.	T.	FREQ.	DUR.	T.
1	3	6	9	12	15	17	20	21	22 26	28 32	34	40	44	47	50	51	54	57
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										
							S	S										

OIL SANDS SOURCE EMISSION INVENTORY

MOBILE SOURCE DATA UPDATE FORM

YEAR	AREA CODE		LOCATION CODE		EXP. CODE	OWN-SHP. ACT.	SOURCE	CARD	TRAFFIC VOLUME	TIME	MEAN SPEED KM/H	MEAN DISTANCE KM	VEHICLE CATEGORY BREAKDOWN				VEHICLE KM PER DAY	ENGINE SIZE AND TYPE OR FUEL CONSUMPTION	OPERATING HOURS PER YEAR
	E	N	E	N	E N								ONE	TWO	THREE	FOUR			
1	3	6	9	12	15	17	20	21	22	26	27	30	34	37	40	43	46	51 55 60	64 70
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											
							M	M											

OIL SANDS SOURCE EMISSION INVENTORY

NATURAL SOURCE DATA UPDATE FORM

YR	AREA CODE		LOCATION CODE		EXP CODE EN	OWN/ ACT CODE	S T	T Y P	CONIFEROUS	DECIDUOUS	BUSH	MUSKEG	MARSH	OPEN WATER	BARE SOIL		OTHER
	E	N	E	N													
1	3	6	9	12	15	17	20	21	22 27	28 33	34 39	40 45	46 51	52 57	58 63	64	65 69
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									
							N	N									

OIL SANDS SOURCE EMISSION INVENTORY

FUGITIVE DUST SOURCE DATA UPDATE FORM

YR.	AREA CODE		LOCATION CODE		EXP CODE EN	OWN/ ACT. CODE	S T.	T Y P.	FRACT. SILT	PREC. INDEX	NO. OF SOURCE	AV. SC VEL.
1	3	6	9	12	15	17	20	21	22	26	29	32
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				
							F	F				

OIL SANDS SOURCE EMISSION INVENTORY

TEMPORAL VARIATION PARAMETERS UPDATE FORM

YR	AREA CODE		LOCATION CODE		MAG CODE	AREA TYPE	S T	T Y P	WINTER	SPRING	SUMMER	FALL	MAXIMUM MONTHLY	MAXIMUM DAILY	MAXIMUM INSTANTAN- -EOUS	C DV	OVERALL EFF.
	E	N	E	N													
1	3	6	9	12	15	17	20	21	22	28	34	40	46	52	58	64	65 67
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									
								Y									

OIL SANDS SOURCE EMISSION INVENTORY

EMISSION DATA UPDATE FORM

YR.	AREA CODE		LOCATION CODE		EXP CODE	OWN/ ACT.	S T.	T Y.	COMPONENT			COMPONENT			COMPONENT			COMPONENT			COMPONENT		
1	E 3	N 6	E 9	N 12	EN 15	CODE 17	20	P 21	CODE 22	QUANTITY 24	M 30	CODE 31	QUANTITY 33	M 39	CODE 40	QUANTITY 42	M 48	CODE 49	QUANTITY 51	M 57	CODE 58	QUANTITY 60	M 66
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															
								X															

11.2 SAMPLE REPORT GENERATOR INPUT WITH REPORTS GENERATED.

OIL SANDS SOURCE EMISSION INVENTORY
REPORT SELECTION FORM

CARD CODE	REPORT NUMBER	REPORT INDICATOR
0SSESLCT	GA	08
1 8	9	11

REPORT NUMBER — 01 FUGITIVE DUST SOURCE LISTING
02 MOBILE SOURCE LISTING
03 NATURAL SOURCE LISTING
04 STATIONARY SOURCE LISTING
05 TEMPORAL VARIATION PARAMETERS LISTING
06 EMISSION DATA LISTING
07 COMPLETE LIST OF SOURCE RECORD SHOWING SOURCE, TEMPORAL VARIATION PARAMETERS, AND EMISSION DATA.
08 SUMMARY OF EMISSIONS

REPORT INDICATOR — TWO CHARACTER IDENTIFIER TO DIFFERENTIATE BETWEEN SEPARATE REPORTS WITH THE SAME REPORT NUMBER.

	YEAR	AREA CODE E N	LOCATION CODE E N	OWNERSHIP/ ACTIVITY CODE	SOURCE TYPE
A 13	76 14	16 19	22 25	2 28	31
	32	34 37	40 43	46	49
	50	52 55	58 61	64	67

	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT
B	01	2	03	2	06	2	07	2	08	3	09	2	14	3
13	14	16	17	19	20	22	23	25	26	28	29	31	32	34

OIL SANDS SOURCE EMISSION INVENTORY
REPORT SELECTION FORM

CARD CODE	REPORT NUMBER	REPORT INDICATOR
0 S S E S L C T	68	08
1 8	9	11

REPORT NUMBER —	01	FUGITIVE DUST SOURCE LISTING
	02	MOBILE SOURCE LISTING
	03	NATURAL SOURCE LISTING
	04	STATIONARY SOURCE LISTING
	05	TEMPORAL VARIATION PARAMETERS LISTING
	06	EMISSION DATA LISTING
	07	COMPLETE LIST OF SOURCE RECORD SHOWING SOURCE, TEMPORAL VARIATION PARAMETERS, AND EMISSION DATA.
	08	SUMMARY OF EMISSIONS
REPORT INDICATOR —		TWO CHARACTER IDENTIFIER TO DIFFERENTIATE BETWEEN SEPARATE REPORTS WITH THE SAME REPORT NUMBER.

	YEAR	AREA CODE E N	LOCATION CODE E N	OWNERSHIP/ ACTIVITY CODE	SOURCE TYPE
A	76			2	
13	14	16 19	22 25	28	31
	32	34 37	40 43	46	49
	50	52 55	58 61	64	67

	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT	COMPONENT CODE	UNIT
B	23	2	26	2	29	2	35	1	99	3				
13	14	16	17	19	20	22	23	25	26	28	29	31	32	34

12. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs within the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters Upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigation into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather, a Feasibility Study
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant
14.	HE 2.4	Athabasca Oil Sands Historical Research Design (3 volumes)
15.	ME 3.4	Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Alberta Oil Sands Region Stream Gauging Data
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Evaluation of Organic Constituents
21.		AOSERP Second Annual Report, 1976-77
22.	HE 2.3	Maximization of Technical Training and Involvement of Area Manpower
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 4.2.1	Review of Dispersion Models and Possible Applications in the Alberta Oil Sands Area
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP study area, March 1976
28.	VE 2.1	Interim Report on a Soils Survey in the Athabasca Oil Sands Area.
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area.

These reports are not available upon request. For further information about availability and location of depositories, please contact:

Alberta Oil Sands Environmental Research Program
15th Floor, Oxbridge Place
9820 - 106 Street, Edmonton, Alberta
T5K 2J6