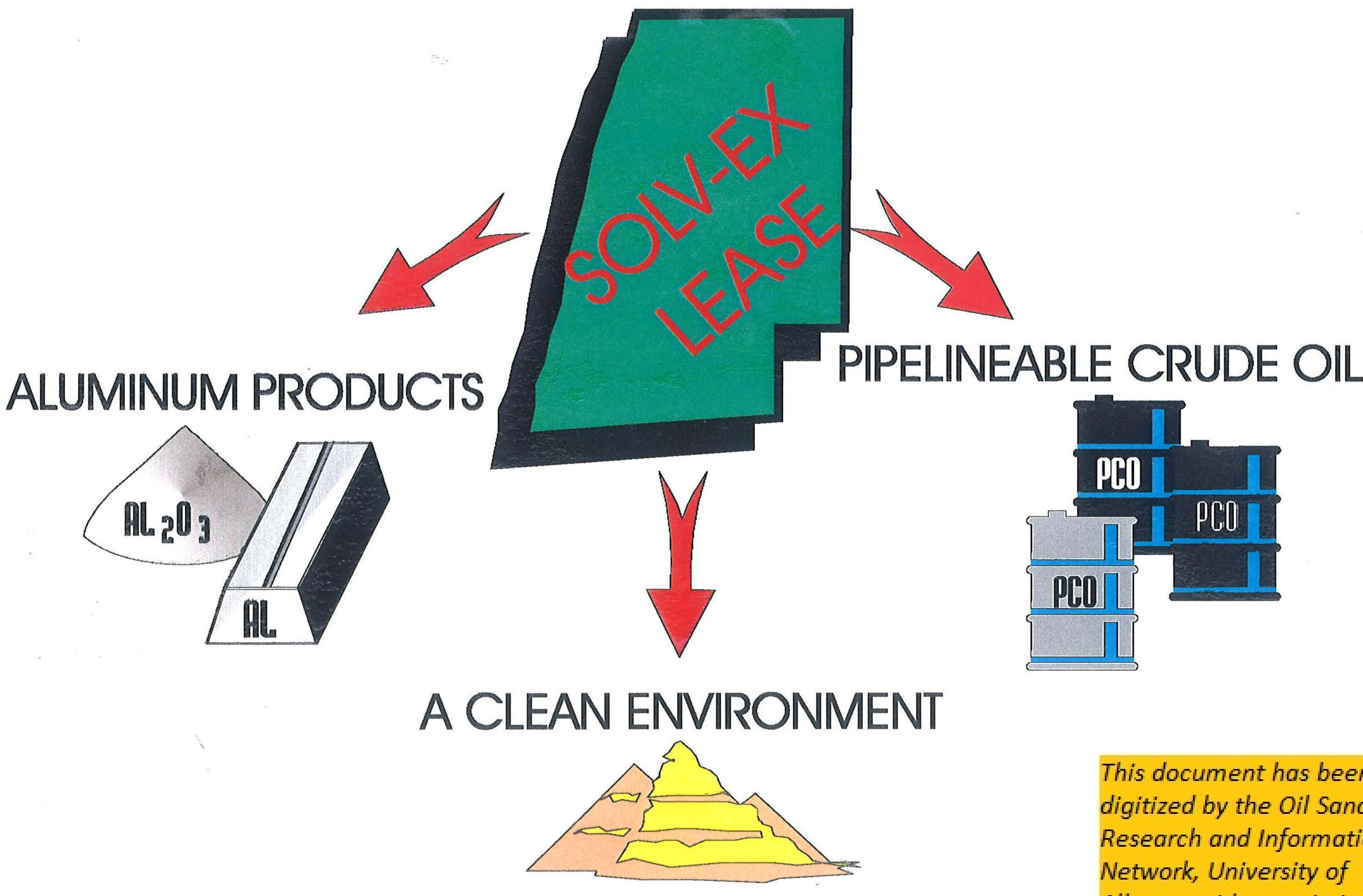
SOLV-EX CORPORATION

OIL SANDS CO-PRODUCTION EXPERIMENTAL PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT



JUNE 1995

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE SOLV-EX OIL SANDS CO-PRODUCTION EXPERIMENTAL PROJECT

Prepared for:

SOLV-EX CORPORATION

Prepared by:

BOVAR-CONCORD Environmental

In Association with

AGRA Earth & Environmental
Hydroconsult EN3 Services Ltd.
Fedirchuk, McCullough & Associates Ltd.
and
R.L.&L. Environmental Services Ltd.

June 1995

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June 28, 1995

SOLV-EX Corporation
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Attention: Mr. Herb Campbell,
President

Dear Sir:

Subject: ENVIRONMENTAL IMPACT ASSESSMENT OF THE SOLV-EX OIL SANDS CO-PRODUCTION EXPERIMENTAL PROJECT

We am pleased to submit the **Environmental Impact Assessment** of the Solv-Ex Oil Sands Co-Production Experimental Project. This assessment has been undertaken by a team of specialists under the direction of BOVAR-CONCORD Environmental. The conclusions contained in this impact assessment are those of the individual specialist, and they are based on the technical and operational information provided by Solv-Ex plus the work and experience of the consulting team with oil sands development in northeastern Alberta.

We wish to acknowledge the constructive contribution of Fort McKay Environmental Services to the impact assessment process by providing the information on traditional resource use and labour force survey in your project area.

Our report may now be filed with the Alberta Energy and Utility Board and other regulatory agencies. We look forward to discussing this work with the government and the public.

Yours truly

BOVAR-CONCORD Environmental

Judith Smith
Manager
Assessment Planning

BOVAR-CONCORD Environmental

Don L. Dabbs
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Attachment

c.c. Aldo Corti, SOLV-EX Corporation

ACKNOWLEDGEMENTS

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We would also like to thank Alberta Environmental Protection, Fort McKay Environmental Services and The Pembina Institute for reviewing earlier Drafts of the EIA, and providing comments on the completeness and clarity of the content of the document.

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Dr. James Case, Mr. Rick Connery and Mr. Richard Rowell were responsible for the Geographic Information System that was used in the Application, and in preparing the maps and figures. In addition, Ms. Maureen Parsons, Ms. Judith Buddle and Ms. Anne Eccles were instrumental in assembling and preparing the Environmental Impact Assessment.

EXECUTIVE SUMMARY

Solv-Ex Corporation is applying to the Alberta Energy and Utility Board (AEUB) for a seven year approval to construct and operate an experimental oil sands co-production facility from November 1995 to October 2002. The facility will be used to evaluate the feasibility of a new co-production technology for the production of Pipelineable Crude Oil (PCO) from the Athabasca oil sands and minerals from fine clay also found in the McMurray Formation. Production levels will be 1674 cubic metres per stream day (m^3/sd) of PCO, 64 000 metric tonnes per year (t/y) of alumina, 12 000 t/y of potassium sulphate and 14 000 t/y of ferrous sulphate. The site for the proposed mine and plant is Solv-Ex owned Lease 7276120T05 (Lease 5) located 85 km north of Fort McMurray and 20 km north of Fort McKay).

PROJECT COMPONENTS

The Solv-Ex Project is comprised of the following components:

- A 50 ha surface mine that will provide bitumen for 6 years. Oil sands will be mined with front shovel excavators on several benches and hauling trucks.

- A 50 ha external mine waste dump area for storage for gravel resources, overburden and central reject from the mine and oversized rock rejects from the bitumen extraction facilities.

- A 42 ha plant site for the extraction and upgrading of bitumen to PCO and the extraction of minerals (aluminum oxide, ferrous sulfate and potassium sulfate) from fine clay tailings. Bitumen extraction will use a hot water process (without caustic or solvent), bitumen upgrading will use a soaker visbreaking process and mineral extraction will use sulphuric acid leaching, salt crystallization and calcining processes. The plant site will support facilities for the conventional amine contacting and Claus processes for fuel gas sweetening and sulphur recovery for sulphuric acid manufacturing, for steam and electricity generation, for water treatment, for water and muskeg storage sites, and for the office facilities and construction/operation camp.

- A 100 ha dyked disposal area for storage of dry tailings (primarily sand with some silt) from the bitumen and mineral extraction processes. Water will be removed from the dyked area and recycled to the bitumen extraction facilities for reuse in slurrying. Excess clay cake produced in bitumen extraction and not required in mineral extraction will be disposed by truck to the tailings disposal area.

- Utilities or resources required to support the mine and plant site are outlined below:

  - Energy sources will be fuel gas (generated in the upgrading process), and natural gas or diesel fuel. Natural gas could be supplied by a pipeline from the southern boundary of Lease 13, while diesel fuel would be trucked to the site.

  - Electrical power during construction will be provided through a diesel powered electrical generator. Electric power during operations will be generated by gas turbines. Steam for process heating and utilities will be generated in the utility building by steam generators fuelled with natural gas or diesel fuel.

  - Make-up water to meet plant requirements will be obtained from the Athabasca River through a shore-based water intake structure and pumped to the plant site through a pipeline.

  - Utility and instrument air will be provided through compressors.

  - Nitrogen will be either produced on-site through a gaseous generation facility, or trucked to site in liquid form.

  - Gravel will be provided from the existing Alberta Transportation and Utilities gravel pit south of the proposed plant site.

  - Elemental sulphur will be purchased from outside suppliers, once the sulphur block inventory has been consumed, and trucked in molten state to the plant.

- Management of other wastes and by-products will involve:

  - Waste water recycling will be maximized. However, some waste water (sanitary waste, surface drainage and potentially saline aquifer water) will be discharged to the Athabasca River through the shore-based water outlet structure. All waste water will be treated to meet Surface Water Quality Objectives of Alberta Environmental Protection (AEP) before being discharged.

  - Garbage will be compacted and transported by truck to an AEP approved landfill. Over the longer term, Solv-Ex may make a separate application under AEPEA for an on-site industrial landfill.

  - By-product pitch will be stored as blocks on clay-lined or concrete/asphalt ground pads within the plant site for possible future use as fuel or in a higher conversion upgrading technology. By-product elemental sulphur will be stored as blocks within the plant site on clay-lined or concrete/asphalt ground pads and used in the mineral extraction process. Surface and subsurface drainage from these two storage sites will be collected and routed to the lined surface drainage retention pond. It will be released to the plant perimeter ditch if it meets AEP requirement, or directed to the process water system.

- A utility corridor that will support an upgraded access road, and a natural gas pipeline, both of which will be constructed and operated by proponents other than Solv-Ex. Access to the proposed project site will be provided by building a road within the existing, cleared right-of-way for Highway 63.

- Transportation of materials will include:

  - PCO and mineral products will be trucked from Lease 5 to markets.
  - Diesel fuel, molten sulphur and chemicals will be trucked to Lease 5.
  - There are no airstrips, or boat launches/landings associated with the Solv-Ex project.

- A construction work force of up to 350 people and an operations work force of up to 350 will be required. A construction camp housing up to 250 people will be built within the plant site.

A total of 331 ha of land will be disturbed for Solv-Ex facilities, including 296 ha within Lease 5 and 35 ha within the 90 m wide utilities corridor for the road upgrade and pipeline.

MINE SETBACK FROM ATHABASCA RIVER

Solv-Ex is making application for approval for a preferred mine location, where the proposed setback of the mine from the Athabasca River ranges from 50 to 100 m. The mine is located in the Athabasca-Clearwater Resource Management Area (*Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan* (IRP); Alberta Environmental Protection 1994). The IRP states that, within this RMA, exploration and development of oil sand resources in the Athabasca River valley will be considered only if the proponent can demonstrate that mitigation of impacts can be achieved.

Field programs that have been conducted in the Athabasca River valley in the vicinity of the proposed Solv-Ex mine include: wildlife ungulate aerial and track counts (February 1995), rare plant inventory (June 1995), tree coring (June 1995), and vegetation and soil mapping (June 1995). These programs indicate that:

- There is no defined valley break in the vicinity of the proposed development,
- No islands in the Athabasca River will be affected by the development,
- There are no rare plants,
- There are no important ungulate wintering, or critical habitat areas,
- There is no old growth forest, although a narrow band (maximum width of 50 m) of white spruce, some > 150 years of age, was identified below the river escarpment. None of these trees will be affected by the mine development, and
- There are no unique soils.

Further field investigations of the location will be pursued by Solv-Ex in 1995:

- Drilling to determine the geotechnical stability of the Athabasca River bank,
- Survey for "springs",
- Rare animal inventory,
- Pellet group and browse inventory to determine ungulate use of area, and
- Historical resource inventory.

Information from these programs will be presented to Alberta Environmental Protection so that the setback of the Solv-Ex mine from the Athabasca River can be finalized.

EXISTING BASELINE CONDITIONS

Biophysical Resources

- Level to gently undulating topography is typical for much of the area, with terrain sloping towards the Athabasca River. Lower Cretaceous near-surface bedrock underlies the Local Study Area (LSA) and include the McMurray Formation oil sand with minor siltstone and claystone, and Clearwater Formation marine shale and glauconitic sandstone. Surficial geology of the LSA consists of two main deposits; glaciofluvial outwash and ice contact kame moraines (Fort Hills).

- Soil types in the LSA consist of, in decreasing abundance: Brunisolic soils developed on sandy textured glaciofluvial and morainal deposits, Organic soils, Gleysolic soils and Regosolic soils.

- Surface water resources in the LSA are predominantly the Athabasca River and Fort Creek. Water will be withdrawn from and discharged to the Athabasca River, while Fort Creek will not be affected by the project.

- Five aquifers occur in the study area: surficial, McMurray, Basal, Methy and La Loche. Groundwater flow can be identified as shallow, intermediate and regional.

- Vegetation mapping to Phase 3 standards, was completed for the LSA. The most common vegetation types in decreasing abundance are: black spruce forest (21%), aspen forest (17%) and white spruce forest (11%).

- Important regional habitat for moose occurs in the BCESA, that includes the Fort Hills and the Calumet Plains. The Athabasca River, and McClelland and Kearl lakes provide important habitat for birds within the BCESA. Special status species that could occur in the region include: whooping crane, peregrine falcon, white pelican, great gray owl, short-eared owl, wolverine, Canada lynx and river otter. Although Key Area Maps illustrate critical areas for wintering moose along the Muskeg and Athabasca rivers within the LSA, February 1995 inventories in the vicinity of the mine indicated low browse levels. More common terrestrial furbearers and carnivores in the LSA are snowshoe hare, red squirrel, fisher, weasel, fox, coyote, lynx and marten. Spruce and ruffed grouse are present.

- The Athabasca River borders Lease 5 for about 7 km. The Athabasca River and its tributaries provide important spawning, feeding, and rearing areas for a number of fish species, and is believed to play a major role in the maintenance of the fish populations of Lake Athabasca.

- The BCESA is located in the Green Zone of Alberta, which contains forested lands that are managed for multiple uses, including forest production, water, recreation, fish and wildlife and industrial development.

Historical Resources

Lease 5, in which the proposed Solv-Ex Facility is located, has received only cursory examination for archaeological sites. No historical resource sites have been identified to date. Archaeological reconnaissance in the LSA portion of Highway 63 between 1977 and 1980 have identified 23 sites. The Bitumount Historic Site is located adjacent to the proposed Solv-Ex development site.

Socio-Economic Conditions

The existing socio-economic conditions in the Fort McMurray, Fort McKay and Fort Chipewyan, as the primary impact communities are reviewed. This includes an overview of the historical development of the region and the existing condition of the study area's population, economy and labour, infrastructure and transportation, education, health and culture and law enforcement. It is not anticipated that other regional communities will be directly affected by the project due to its small size, short duration and experimental nature.

Regional Population

The primary study area communities are Fort McMurray and Fort McKay. The downstream community of Fort Chipewyan is also profiled. Fort McKay and Fort Chipewyan are Aboriginal communities while Fort McMurray has grown to become an important regional centre based on servicing the area's two commercial oil sands developments at Suncor and Syncrude. The communities in the study area share a common regional identity based on their traditional historical and cultural ties and participation in a common economic system. These communities began as trading posts and church mission sites, but later became the focus of permanent settlement and government administration.

In the 1991 census, the population of the City of Fort McMurray was determined to be 34 706 persons. Ethnically, Fort McMurray has become a diverse, multicultural community. The size of the Aboriginal community is significant, with 1795 people making up about 5.2% of the population total in 1991.

The Fort McKay municipal census was taken by I.D. #18 in March, 1995 and indicated a total community population of 332 people. Local community administrators in 1989 held that the population was about 350 persons (Syncrude SEIA 1992). There appears to have been no major population increase in the community of Fort McKay in the 1989-1995 period. Some 93.7% of the population are reported to have an Aboriginal heritage (includes Metis). There are no other significant minority ethnic groups in the community.

Fort Chipewyan is located at the western tip of Lake Athabasca, about 220 km north of Fort McMurray. Established in 1728 as a fur trading post, it is the oldest community in Alberta, initially serving as headquarters for trading activity to the frontiers north and west of the community. The current local population was estimated at approximately 1200 to 1400 persons in discussions with local officials. A best estimate is that 75 to 85% of the community is Aboriginal. Similar to the Fort McKay case, there are no other significant minority ethnic groups in the community.

Regional Economy and Labour Force

As with much of Northern Alberta, the study area economy is driven by activity in the primary industries. These industries include agriculture, mineral and hydrocarbon production, forestry, and commercial fishing and trapping. The remaining economic activity in the region can be attributed to the following secondary and/or tertiary industries: manufacturing, construction, transportation, communication and utilities, trade, finance, insurance and real estate, community business and personal service, and public administration and defence.

The oil sands mining and processing industry dominates the regional economy and to a large extent its health and prosperity is a good predictor of that of the economy as a whole. The region has gone through a series of cycles of optimism and pessimism related to new large scale oil sands proposals such as Alsands, Canstar and OSLO which have failed to come to fruition. However, the current view looks relatively optimistic.

The community of Fort McKay has had a long association with the development of oil sands facilities in the region. The community of Fort McKay completed a "Current Labour Force" survey in April, 1995. It shows clearly that the current workforce of Fort McKay is oriented towards participation in the oil sands, construction and transportation industries. The community of Fort McKay, through its community-owned business ventures - the Fort McKay Group of Companies - also actively participates in the economic benefits of oil sands development.

The community of Fort Chipewyan has only limited winter road access to the project area and has thus had only a peripheral association with the economic development of oil sands facilities in the region. The community also suffers from chronic unemployment/underemployment problems. In 1991, the census indicated that the largest economic sector in Fort Chipewyan was government services. All other sectors had only minor inputs into the local economy. The community's Aboriginal organizations are active in promoting economic development and the community currently supplies workers to existing oil sands operations on a fly in/out rotation.

Regional Infrastructure and Transport

The state of the housing market in Fort McMurray is currently characterized by substantial excess capacity, both in terms of developed land and vacant units. As a result of Fort McMurray's previous experience as a high-growth resource community and the long-standing possibility that additional growth would be triggered by another oil sands project, the City has prepared itself well, in terms of major infrastructure, to accommodate the growth associated with the Solv-Ex project.

The regional transportation network consists mainly of an all-season paved Highway 63 from the Edmonton-area to Fort McMurray. The highway is used extensively by residents and commercial concerns to transport goods from the south. North of Fort McMurray, the highway also serves two other primary purposes: first, as the link between the residential communities of Fort McMurray and the Suncor and Syncrude Oil Sands Plants, and second, as the major economic and social conduit between the communities of Fort McMurray and Fort McKay.

The community infrastructure in Fort McKay consists of a school, nursing/medical station, store and tribal office facilities. Community infrastructure in Fort Chipewyan consists of 2 schools, a hospital, several stores and government offices. These facilities are adequate for the existing population base.

Regional Health and Culture

Socio-cultural issues in Alberta's Aboriginal communities relate to differences and accommodations between the traditional Aboriginal culture and contemporary Canadian culture. In Fort McMurray, cultural issues relate to community life in the multicultural society. It seems clear to all that the community, which was somewhat raw and "unfinished" at the beginning of the 1980s, has now "come of age".

The majority of physical health care facilities available in the study area are located in Fort McMurray. Physical health needs of people in Fort McMurray and northeast Alberta are primarily served by the recently formed Northern Lights Regional Health Authority which includes the Fort McMurray Region General Hospital, the Fort McMurray and Regional Health Unit and emergency medical service units.

As is true of many communities in North America generally, substances abuse is a significant problem in the study area. Fort McMurray has as impressive a set of resources for dealing with substance abuse problems as any small city in the province. This level of resources is necessary, however, because the Fort McMurray resources serve the needs of all residents of northeast Alberta, as well as because the population is at elevated risk because of its distinctive composition and economic situation.

Before construction of the Suncor plant, the people of Fort McKay were able to enjoy a "post-contact traditional" lifestyle, harvesting wild plant and animal resources, exchanging furs for trade goods, etc. Development did not seriously challenge the more traditional cultural patterns of Fort McKay residents until the last 10 or 15 years, since many continued in traditional harvesting. The last ten years have seen many more people able to obtain oil sands-related employment, and inevitably there has been less pursuit of traditional resource harvesting. There is now increasing interest among community residents in both wage employment and traditional resource harvesting.

ENVIRONMENTAL PROTECTION PLANS AND RESIDUAL IMPACTS

The environmental protection plans (including design features, mitigation and compensation, and monitoring programs), along with the residual impacts to biophysical resources, historic resources and socio-economic resources are summarized in Table 1. Definitions of the terms used to rate the Degree of Concern of impacts are presented in Table 2.

The impacts of highest concern are:

- Long-term reductions in the levels of surficial and basal aquifers, especially in the vicinity of the end-pit lake where the water table is expected to stabilize at lower than pre-disturbance levels. The effects are limited in spatial extent to the vicinity of the mine and plant site.

- Potential limited hydrocarbon contamination of groundwater due to seepage from the hydrocarbon tank and the tailings disposal areas.

- The necessary disturbance of 331 ha of natural landforms, soil and vegetation by construction and operation activities, and the replacement of 287 ha of new landforms, soil of equivalent capabilities and early to mid-successional vegetation types (that will eventually succeed to more mature climax plant communities) through reclamation. The effects are considered moderate in magnitude, and moderate to long-term in duration.

- The loss of wildlife through traffic collisions and increased hunting pressures, and of wildlife habitat through to vegetation clearing and alienation. These impacts are considered moderate to high in magnitude, and the effects of habitat loss will last many years after the Development Area has been reclaimed and abandoned.

- The interruption of resource use activities such as berry picking, and the reduction in aesthetics of the area due to the visual intrusion from the road of the Solv-Ex plant and mine facilities.

- The "primary" effects of the Solv-Ex project on historical resources are expected to be low to moderate in magnitude, even though an HRIA will be conducted.

- The socio-economic impacts of high or moderate magnitude are:

  - Increased employment and business opportunities, and training opportunities for Fort McKay during the construction and operations phase of the Solv-Ex project, which are removed after the project is completed,

- Increased use of housing in Fort McMurray by Solv-Ex employees,
- Increased traffic on Highway 63,
- Increased wage incomes that could lead to increases in the consumption of alcohol and/or illegal drugs.

Three undetermined impacts were identified:

- The potential for the exchange of water between the mine and the Athabasca River has not yet been determined. Geotechnical investigations through drilling in 1995 will be used to evaluate this potential impact, and potential effects on the flow or quality of the Athabasca River. If necessary, Solv-Ex will engineer mitigation to minimize water flow into the mine, and thus ensure pit integrity and worker safety.

- The interactive effects of O_3 alone, and SO_2, NO_x and O_3 on plant growth and yield are difficult to predict due to the variability of responses amongst plant species and to various concentrations.

- The extent of use of the wildlife movement corridor along the Athabasca River is not known, and thus the effect of the Solv-Ex operation is difficult to predict. If necessary, a vegetated berm will be constructed along the west edge of the mine to minimize disturbance to wildlife.

Solv-Ex Corporation has made a commitment to sound environmental management and, therefore, the environmental protection plans outlined in Table 2 are central to the reduction of impacts associated with the co-production facilities. Full implementation of the protection plans will ensure that the project impacts are properly managed. The experimental project offers many environmental advantages such as reduced sulphur emissions and dry tailings. Monitoring the operation and associated impacts will confirm these advantages, and ensure that a commercial scale plant can also operate with reduced and carefully managed impacts.

Table 1. Terms used in Degree of Concern of Impacts Ratings for the Environmental Impact Assessment.

Magnitude of Impact[a]	Direction of Impact[b]	Duration of Impact[c]	Frequency of Impact[d]	Scope (Geographical Extent) of Impact[e]	Degree of Reversibility of Impact[f]
Low (< 1%)	Positive	Short-term (< 1 year)	Once	Local	Reversible
Moderate (1 - 10%)	Negative	Moderate (1 to 7 years)	Intermittent	Regional	Irreversible
High (> 10%)	Neutral	Long-term (> 7 years)	Continuous	Provincial	

(a) **Magnitude** refers to the percentage of a population or resource that may be affected. Where possible, the population or resource base has been defined in quantitative or ordinal terms (e.g., hectares of soil types, units of habitat). Impact magnitude has been classified as either less than (<) 1%, 1 to 10%, or greater than (>) 10% of the population, or resource base. If there is insufficient information available to quantify the percent impacted, the change has been identified only as an increase or decrease in the population or resource.

(b) **Direction** refers to whether an impact to a population or resource is considered to be a positive, negative or neutral effect.

(c) **Duration** refers to the time it takes a population or resource to recover from the impact. It is to be identified as short-term (< 1 year), moderate-term (1 to 7 years) and long-term (> 7 years).

(d) **Frequency** refers to the number of times an activity occurs over either the construction phase or the operations phase, and can be identified as once, intermittent, or continuous.

(e) **Scope** refers to the geographical area potentially affected by the impact and may be rated as local (Within Local Study Area), regional (Within Biophysical Cumulative Effects Study Area, or Air Resources Cumulative Effects Study Area), or provincial (extends outside Regional Study Areas). Where possible, quantitative estimates of the surface area affected by the impact has been provided.

(f) **Degree of Reversibility** refers to extent an adverse effect is reversible or irreversible over a 7 year period.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project.

A. AIR QUALITY

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Increased Ambient SO_2 Concentrations Deposition of Acid-Forming Compounds	• SO_2 emissions associated with normal Phase I and II operations are expected to be about 1.47 and 9.82 t/d, respectively. • A sulphur recovery plant with a long-term recovery efficiency of 98% will reduce SO_2 emissions. • A normal 99% SO_2/SO_3 converter in the acid plant will reduce SO_2 emissions. • The sour water stripper overhead is directed to the sulphur recovery plant to reduce SO_2 emissions. • Acid plant scrubber stream will be combined with sulphur recovery incinerator exhaust streams and vented through a common stack to increase plume rise. • Prudent operatorship and maintenance procedures will help minimize the flaring of sour gas streams.	**Life of Operation:** • Maximum SO_2 concentrations as a one-hour average are expected to be in the 126 to 419 $\mu g/m^3$ range. The corresponding guideline for SO_2 is 450 $\mu g/m^3$. These maximum values are predicted to occur within 4 km of the plant. • Maximum daily average SO_2 concentrations are expected to be in the 74 to 106 $\mu g/m^3$ range. This compares to the guideline value of 150 $\mu g/m^3$ of SO_2. • Maximum annual average SO_2 concentrations are expected to be in the 3.4 to 7.0 $\mu g/m^3$ range. This is below the 30 $\mu g/m^3$ guideline for SO_2. • Because of the Suncor SO_2 reduction program, the background maximum total deposition in the region is expected to be 9.9 kg/SO_4^{-2}/ha/a (EA = 0.28 kmol H^+/ha/a). In the vicinity of the plant, the background maximum EA is 0.15 kmol H^+/ha/a. • The operation of the Solv-Ex facility will increase the background level in the vicinity of the plant by up to 3.13 kg/SO_4^{-2}/ha/a (EA = 0.14 kmol H^+/ha/a). The EA in the vicinity of the Solv-Ex plant (under Suncor's reduction program) is 0.20 kmol H^+/ha/a.
2. Increased Ambient NO_x Concentrations	• NO_x emissions associated with Phase II operations are expected to be about 0.65 t/d and 1.06 t/d for the diesel oil and natural gas combustion alternatives.	**Life of Operation:** • The maximum one-hour average NO_2 concentrations resulting from the proposed Solv-Ex Operation is about 95 $\mu g/m^3$. This value is predicted to occur on the plant site and is below the 400 $\mu g/m^3$ guideline for NO_2.
3. Increased Particulate Concentrations	• Particulate emissions from stationary sources are expected to be 0.74 t/d and 0.88 t/d from the natural gas and diesel oil combustion alternative. • The double salt dryer, $FeSO_4$ dryer and K_2SO_4 dryer are equipped with bag filters and/or wet scrubbers to reduce particulate emissions. • Venturi scrubber servicing the clay dryer, agglomerator and cure drum will reduce particulate emissions.	**Life of Operation:** • The maximum daily average particulate combustion resulting from the proposed Solv-Ex operation is 97 $\mu g/m^3$ with screening meteorology. SandAlta meteorology prediction is 50 $\mu g/m^3$. This is less than the 100 $\mu g/m^3$ TSP guideline.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

A. AIR QUALITY (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
4. Increased CO_2 Emissions	• Stationary and mobile CO_2 emissions are expected to be up to 357 and 1162 t/d for Phase I and Phase II, respectively. Energy utilization practices to increase efficiency and reduce CO_2 emission include: - waste heat recovery exchangers - concurrent power and steam generation (co-generation) - internal recycle of process water.	**Life of Operation: (Continued)** • CO_2 emissions released from Solv-Ex are estimated to be 1162 t/d. CO_2 emissions have been related to global scale climate changes.
5. Increased Noise Levels	• Processes and equipment generating noise will be put in buildings or enclosed to attenuate noise levels. • There are no engine-driven compressors.	**Life of Operation:** • Off-site noise levels beyond 1.5 km will meet the AEUB guideline of 40 dBA Leq.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

B. WATER AND AQUATIC RESOURCES

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Surface Water Flows and Quality (Figure 5.13)	• A buffer zone of undisturbed land and vegetation will be retained along the Athabasca River to prevent erosion and sedimentation. • Sediment control ponds (including end-pit lake during abandonment phase) will be used to reduce sedimentation in the Athabasca River. • No effluent will be released to the Athabasca River unless it meets AEP's Surface Water Quality Objectives. • A gated culvert in Highway 63 will be designed so it can be shut-off to contain potential spills. • A water licence from AEP will be required for water withdrawals from the Athabasca River. • Plant site runoff will be collected and recycled into the plant operation to the fullest extent, to minimize water withdrawal from the Athabasca. • The following surface water monitoring program will be undertaken: - Water withdrawals from the Athabasca will be monitored and recorded at the pumphouse at the Athabasca River, - The total flow returned to the Athabasca River via the small drainage at the plant site will be monitored at the gated culvert at Highway 63, - If the dewatering from the mine is discharged directly into the Athabasca River, the rate will be monitored at the pumps in the mine, - Releases from on-site ponds will be monitored in accordance with AEP regulations, and - During any plant upset conditions which result in releases to the external environment, water quality will be continuously monitored as deemed necessary until normal operations are resumed.	**Life of Operation:** • Withdrawal of water from the Athabasca River, for plant make-up will reach a maximum of 5.0 Mm^3 per year and will require a Licence under the Water Resources Act. There could be up to a maximum 0.2% decrease in Athabasca River flows during the lowest recorded flow month, if this occurred coincident with startup, due to these withdrawals. This impact is considered Low in magnitude, Negative, Moderate-term in duration, Regional in geographic extent, Continuous and Irreversible during the operations phase. • The potential for exchange of water between the mine and the Athabasca River has not yet been determined. Geotechnical investigations through drilling in 1995 will be used to evaluate this potential impact, and potential effects on the flow or quality of the river. If necessary, Solv-Ex will engineer mitigation to minimize water flow into the mine, and thus ensure pit integrity and worker safety (Undetermined Impact). **Post-Operation:** • Surface drainage will be re-established in the Development Area through the re-development of portions of original streams, and the development of a new end-pit lake. This impact is considered Low in magnitude, Positive, Long-term in duration and Regional in geographic extent.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

B. WATER AND AQUATIC RESOURCES (Continued).

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
2. Changes in Groundwater Flows and Quality (Figures 5.17 and 5.18)	• To minimize the potential for seepage of contaminants from storage or process areas in the plant site area, storage areas will be lined wherever feasible (e.g., hydrocarbon tank, sulphur and pitch, storage areas). In addition surface and subsurface drainage will be collected and routed to the lined drainage retention ponds. • If a landfill is constructed, it will be designed to AEP standards. • Solv-Ex will join the Area "Y" Environmental Co-operative which will make the oil spill containment and clean-up resources of the Co-operative available to handle any emergencies. • Monitoring wells will be installed at the Lease area to monitor potential impacts on the underlying groundwater quality and changes in groundwater levels. The monitoring program will be designed to meet the requirements outlined in the Clean Water Licence to Operate.	**Life of Operation:** • In the vicinity of the mine and plantsite, there will be a reduction in groundwater levels in the shallow and the upper Cretaceous aquifers. This impact is considered Moderate in magnitude, as the water level will be reduced to the mine base, Negative, Long-term, Continuous, Local in spatial extent and Irreversible during the mining operation. • There will be a reduction in groundwater levels in the basal aquifer, where present, if mine depressurization is required. This impact is considered High in magnitude, Negative, Long-term, Local, Continuous during mining activities, and Irreversible as oil sand is replaced with wash sand. • If seepage of hydrocarbons from the hydrocarbon tank area or the tailings disposal area occur, groundwater quality may be impacted in a limited area. This impact is considered Low to Moderate in magnitude, Negative only if seepage occurs, Short-term if seepage is identified and mitigated, Continuous, Local, and Reversible if seepage is identified and mitigated. **Post-Operation:** • As drainage patterns are re-established and the end-pit lake is filled, groundwater tables in the mine and plant site areas will be restored to pre-development levels, except in the vicinity of the end-pit lake and mined area where the water table is expected to stabilize at lower than pre-disturbance levels. This impact is considered Positive and Long-term (other impacts terms are not applicable).

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

B. WATER AND AQUATIC RESOURCES (Concluded).

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
3. Change in Fish Habitat and Populations (Figure 5.23)	• Avoidance of Fort Creek. • Sediment control ponds and buffer zones along the Athabasca River will be used to reduce sediment levels entering the Athabasca River. • Ensure all water discharged to the river meets Alberta Environmental Protection standards. • Screen water intake to minimize the entrainment of fish from the Athabasca River. • Restore/stabilize Athabasca River banks and establish end-pit lake. The potential productivity and suitability of the end-pit lake for fish should be examined prior to abandonment. • Baseline biophysical data on water quality, fish use, aquatic habitat and macrovertebrate fauna of Fort Creek should be collected because of its association with the Solv-Ex lease and project area.	**Life of Operation:** • Additions of sediment from construction activities and surface drainage to the Athabasca River may decrease local aquatic habitat capability and biota. This impact would be Low in magnitude, Negative, Short-term in duration, Continuous during the construction phase, Local in geographic extent and Reversible. • Additional people associated with the project and improved access along Highway 63 will result in increased fishing pressure and harvest and a decrease fish populations. This impact would be Low in magnitude, Negative, Long-term in duration, Regional in geographic extent and Reversible if populations are not too heavily fished. • Bank protection/stabilization association with the water intake and the shoreline in the vicinity of the mine along the Athabasca River will result in additional aquatic habitat and increased diversity. This impact would be Low in magnitude, Positive, Long-term in duration, Continuous, Local in extent and Reversible. **Post-Operation:** • Development of an end-pit lake at abandonment will create new aquatic habitat. Restoration/stabilization of river banks and possible local stream enhancement may increase fish and aquatic habitat. Habitat restoration and enhancement would be Positive, Long-term, Continuous and Local (other impact terms are not applicable). • Continued increase in fishing pressure may result due to improved access. Although this impact is Negative, it would be Low in magnitude, Long-term and Regional (other impact terms are not applicable).

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. **Changes in Landforms (Figure 5.19)**	• Approximately 317 ha out of the 331 ha of disturbed land will be reclaimed to landforms compatible with the surrounding environment and to meet AEP reclamation guidelines. • Potential for erosion of recontoured disposal areas will be reduced by revegetating disturbed areas as soon as possible.	**Life of Operation:** • There will be a progressive disturbance of 331 ha of landforms during the 7 year operating period of the Solv-Ex project. During operation, reclamation will have been initiated on 20 ha of the mine to re-establish landforms. This disturbance represents 7% of the LSA (Moderate magnitude) and 0.6% of the CESA. • There will be a temporary disturbance of 67 ha of landforms during the 7 year operating period of the Solv-Ex project. The temporary impacts during operation will be Negative, Moderate in magnitude, Moderate in duration, Continuous, Local and Reversible. • There will be a permanent burial of 164 ha of landforms during the operation of the Solv-Ex project. These impacts will be Moderate in magnitude, Negative, Long-term, Once, Local and Irreversible. **Post-Operation:** • There will be a re-establishment of 137 ha of landforms (mine area, access roads, pipelines and plant sites that are similar to the pre-existing landforms). These impacts will be Positive, Moderate in magnitude, Long-term, Once, Local and Irreversible. • There will be 180 ha of new landforms created due to the end-pit lake and waste disposal areas. These impacts will be Moderate in magnitude, Neutral, Long-term in duration, Once, Local and Irreversible. • There will be a permanent loss of 14 ha due to the Highway 63 upgrade. These impacts will be Low in magnitude, Negative, Long-term, Once and Irreversible.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE) (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
2. Changes in Soil Capability (Figure 5.20)	• Progressive clearing of mine site will minimize exposure to erosion. • Sufficient "fair" and "better" organic mineral and sandy soils will be salvaged to meet reclamation needs. • Re-establish soil capability through reclamation. • Establish a monitoring program to examine the physical and chemical characteristics of reclaimed soils in the mine and other disturbed areas: - pH - Electrical conductivity - Saturation percentage - Sodium adsorption ratio - Particle size analyses - Soil structure - Reclamation suitability of horizons. On reconstructed soils, a detailed evaluation of the above parameters will be undertaken to aid in choosing appropriate vegetation seed mixes. Soil chemical and physical characteristics will be analyzed periodically to aid in judging reclamation success. Particular attention will be paid to evaluating soil tilth, as good soil chemistry (low SAR) is not always an assurance that soil physical properties will not limit reclamation success.	**Life of Operation:** • A total of 331 ha of soils will be disturbed during the 7 year operational phase of the Solv-Ex project. This represents a 7% increase in disturbance in the Local Study Area and 0.6% increase in the Biophysical Resource Cumulative Effect Study Area. Soil capabilities will be decreased through soil mixing and burial. Reclamation will restore 287 ha back to equivalent soil capabilities. There will be permanent loss of 44 ha of soils due to the Highway 63 upgrade and the end-pit lake. These residual impacts due to soil mixing and burial will be Moderate in magnitude, Negative, Moderate-term, Continuous, Local, Reversible and Irreversible. • Drainage of soils prior to site development will be required for the Organic and Glysolic soils. Drainage will improve the soil capability. **Post-Operation:** • Reclamation will restore soil capability on 287 ha of the disturbed areas. About 44 ha of soils will be permanently lost due to the Highway 63 upgrade and the end-pit lake. This residual impact will be Low to Moderate in magnitude, Negative, Long-term, Once, Local and Irreversible.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE) (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
3. **Changes in Plant Vigor and Survival, and Vegetation Community Structure and Diversity (Figure 5.21)**	• Clearing and reclamation of the mine site will be phased to reduce the size and area of vegetation disturbed at any one point in time. • Plant communities to be re-established on the 287 ha of reclaimed landscape are: aspen, mixedwood and coniferous (white spruce, jack pine and black spruce). Solv-Ex will consider re-establishing berry-producing shrubs. • Undertake forest fire suppression activities e.g., vegetation will be cleared to provide sufficient distances to limit the potential of fire escape from the Solv-Ex facilities. • A monitoring program will be designed to document the re-establishment of plant species and community types on reclaimed sites. Plots will be established to examine plant species composition.	**Life of Operation:** • There will be a loss of 331 ha (7%) of the vegetation communities within the Local Study Area as a result of site clearing. This will include black spruce (57%), fen (11%), aspen, (9%), aspen/jack pine (8%). This Moderate magnitude, Negative impact will be Local in spatial extent, Phased and Irreversible over the 7 year life of this project (Moderate duration). • The interactive effects of O_3 alone, and SO_2, NO_x and O_3 on plant growth and yield are difficult to predict due to the variability of responses amongst plant species and to various concentrations (Undetermined Impact). **Post-Operation:** • The 331 ha (7%) of the plant communities, within the Local Study Area, lost as a result of site clearing will partially be replaced following reclamation. A portion of the mine will be reclaimed to a 30 ha end-pit lake and 14 ha will be permanently removed due to paving of Highway 63. The remaining 287 ha will be reclaimed to vegetation communities; aspen (127 ha), mixedwood forest (123 ha) and coniferous forests of white spruce, jack pine and black spruce (37 ha). This will increase specific resource values such as aesthetics, timber productivity (400%) or wildlife, but will not completely return the site to the pre-construction species composition or community structure. The impacts will be Positive, Long-term in duration, Local in spatial extent, Moderate in magnitude, Phased and Irreversible, as the capability of the site and the plant species composition will be altered.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE) (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
4. Changes in Abundance of Terrestrial Wildlife (Figure 5.22)	• Clearing and reclamation of the mine site will be phased to reduce the size of the area of habitat disturbed at any one point in time. • Solv-Ex will produce a "no net loss" of habitat policy for wildlife. The disturbed area will be reclaimed to a mosaic of habitat types: aspen forest, mixedwood and open black spruce forest. Other forms of habitat enhancement could be considered during reclamation. • A vegetated berm may be constructed along the west edge of the mine to minimize disruption to the wildlife movement corridor along the Athabasca River. • Have Alberta Fish and Wildlife remove nuisance species (e.g., bears, beaver) from the site. Implement a bear management plan if a landfill is eventually constructed. • Monitoring programs established to examine the composition and structure of vegetation types on reclaimed sites will be used to evaluate the quality and value of habitat for wildlife species. No monitoring programs to assess changes in wildlife population levels are recommended.	**Life of Operation:** • Within Lease 5, a total of 296 ha of habitat will be lost due to vegetation clearing and up to 927 ha due to habitat avoidance (worst case scenario). Within the Utility Corridor a total of 35 ha of habitat will be lost due to clearing, but there will be no increase in habitat loss due to alienation. Habitat loss is considered to be an impact Moderate to High in magnitude, Negative, Long-term in duration, Continuous (due to the phased nature of vegetation clearing and disturbance), Local to Regional in scope, and Irreversible during the Life of the Project. • There will be an increase in wildlife mortality due to wildlife-vehicle collisions as a result of increased traffic levels from the Solv-Ex project, on Highway 63. This impact is considered to be Low in magnitude, Negative, Moderate-term in duration, Continuous through the Life of the Project, Regional in Scope and Reversible if mortality rates remain low. • It is difficult to assess what portion of the moose or canid populations that use the Athabasca River as a movement corridor may be affected by barriers to movement created by development of the mine and other facilities. The construction of a vegetated berm along the west edge of the mine may mitigate this effect (Undetermined Impact). **Post-Operation:** • Over time site reclamation will replace the quality and capabilities of habitat that will be lost due to clearing of the Development Area. However, reclaimed habitat will not provide capability equivalent to pre-disturbance levels for several years after the end of project operation. After a few years, the successional vegetation will provide high quality habitat for species such as moose, bear and hare that depend on early to mid-successional habitat. This impact is considered Moderate in magnitude (7% of LSA), Positive, Long-term in duration, and Local to Regional in scope (other impact terms not applicable). • There may be a decrease in the populations of hunted wildlife species (e.g., moose, upland game birds) due to increased hunting pressures as a consequence of improved access along the upgraded Highway 63 and within the Development Area. This impact is expected to be Low to Moderate in magnitude, Negative, Local to Regional in scope and Long-term in duration (other impact terms not applicable).

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

D. RESOURCE USE

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Food Gathering Opportunities such as Berry Picking (Figure 5.24)	• The early successional vegetation stages will support berry producing shrubs. • No monitoring programs beyond those identified for soil and vegetation (Sections 5.5.2.4 and 5.6.5) are recommended.	**Life of Operation:** • The removal of 294 ha of vegetation that support edible plants and the restricted access to areas that were once accessible, will have a Moderate magnitude (7% of Local Study Area, or an increase of 1% in the Biophysical Cumulative Effects Study Area), Negative impact on traditional food gathering for the duration of the 7 year project. Access outside of this area along existing routes will be maintained. This impact is Irreversible within the life-span of the project (other impact terms are not applicable). **Post-Operation:** • Reclamation of the Development Area will return 287 ha (6% of the Local Study Area) to vegetation will increase the abundance of early to mid succession plants including strawberry, blueberry, chokecherry, rose Labrador tea, currant, cranberry and kinnikinnick. This will positively increase early successional edible plants for a period >7 years, however, the impact of the initial clearing is irreversible over the life of this project (Long-Term).
2. Changes in Timber Harvest Potential (Figure 5.25)	• Merchantable deciduous and coniferous timber will be salvaged during site clearing. • No monitoring programs beyond those identified for soil and vegetation (Sections 5.5.2.4 and 5.6.5) are recommended.	**Life of Operation:** • Approximately 296 ha of forest will be cleared within the Local Study Area. This will include 229 ha of non-merchantable and 67 ha or 6500 m^3 (2% in Local Study Area) of merchantable timber. An additional 355 m^3 of timber volume will be lost from the mine area. Merchantable wood will be salvaged. The disturbance will be phased and due to timber salvage, is classed as Low in magnitude, Negative, Irreversible, Long-term and Local in Scope. • The areas cleared for development will not be regenerated to productive forest during the life of the operation, except for 20 ha of the mine. This Moderate magnitude, Negative impact is a single occurrence with Long-term, Irreversible effects. **Post-Operation:** • Reclamation of the Lease 5 Development Area will return 287 ha of land to productive forest. Merchantable timber volumes will return in 50 years for aspen and between 80 and 100 years for coniferous species. Timber volume regeneration is predicted to have a 400% increase. This impact will be Positive, Moderate in magnitude, Long-term, and Local in Scope. The impacts are Irreversible for a period of greater than 10 years.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

D. RESOURCE USE (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
3. Changes in Fishing Opportunities (Figure 5.26)	• The end-pit lake will be designed to support sportfish, and could be stocked with sportfish. • No monitoring programs are recommended beyond those identified for fish resources (Sections 5.8.4).	**Life of Operation:** • None. **Post-Operation:** • There is expected to be an increase in fishing opportunities in the Local Study Area after reclamation primarily due to creation of the end-pit lake and improved access. This impact is considered Low in magnitude, Positive, Long-term in duration and Local in scope (other impact terms are not applicable).
4. Changes in Hunting and Trapping Opportunities (Figure 5.27)	• The site will be reclaimed to habitat that will support game species, e.g., moose, hare, beaver, etc. • The two trappers affected by the Solv-Ex development will be compensated for the loss of trapping opportunities. • No monitoring programs beyond those identified for wildlife in Section 5.7.5 are recommended.	**Life of Operation:** • There is expected to be a slight decrease in hunting and trapping opportunities in the vicinity of the Local Study Area due to the reduced abundance of terrestrial wildlife and secondarily to reduced access. This impact is considered Negative, Low in magnitude, Local to Regional in scope, Long-term in duration, and Irreversible. **Post-Operation:** • There is expected to be an increase in hunting and trapping opportunities due to the increased abundance of terrestrial game species, and possibly aquatic species, using the reclaimed Development Area. Improved access to the site will be available along Highway 63 and the upgraded winter road. This impact is considered Low in magnitude, Positive, Long-term in duration and Local in scope (other impact terms are not applicable).

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

D. RESOURCE USE (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
5. Changes in Non-Consumptive Resource Use (Figure 5.28)	• No monitoring programs beyond those recommended for vegetation (Section 5.6.5) are recommended.	**Life of Operation:** • Visual impacts will include the removal of 331 ha (7% of the Local Study Area) of forest cover and infrastructure development, mining activities, the development of overburden and tailings piles, and air emissions (including ice fog during the winter and sulphur dust during the first year of operation). To reduce visibility of the development from the Athabasca River, a berm/vegetation screen will be developed along the west edge of the mine. Solv-Ex facilities will be visible from the upgraded Highway 63 and upgraded winter road. This Irreversible, Negative impact will occur continuously during the life of the project (Moderate duration), and is considered Low to Moderate in magnitude (other impact terms are not applicable). • There will be some reduced opportunities for photography and wildlife viewing due to reduced numbers of wildlife and fish, and restricted access. This impact is considered Low in magnitude, due to the low non-consumptive use of site prior to development. These Irreversible, Negative impacts will occur continuously during the life of the project (Moderate duration; other impact terms are not applicable). **Post-Operation:** • The reclaimed landscape, increased abundance of wildlife and fish populations, and improved access will provide increased opportunities for non-consumptive resource use and improve aesthetics. This impact is considered Positive, Low to Moderate in magnitude, Long-term and Irreversible (other impact terms are not applicable). The Positive and visual impacts will be a Long-term duration. This impact is Irreversible and will be continuous.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

E. HISTORICAL RESOURCES

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Impacts on Historical Resources (Figure 7.1)	• Conduct an Historic Resources Impact Assessment of all sites to be disturbed by the Solv-Ex Project.	**Life of Operation:** • Historic sites will occur on, or very near surface. These sites will be identified through the HRIA of the Solv-Ex Development Area. Mitigative activities to minimize the Primary impacts to historic sites include formal documentation/descriptive photography, mapping, artifact collection and/or controlled excavation to retrieve pertinent data on the site and activities. Archival research and documentation may be required. Solv-Ex's management plan to minimize effects on paleontological remains will ensure that the Royal Tyrell Museum of Paleontology is contacted and monitors any significant finds. With these mitigation procedures in place, this impact is considered Low to Moderate in magnitude, will be Negative, Long-term in duration, occur Once and be Irreversible during the life of the project. The scope of impact could occur at all three levels of geographic extent i.e., local, regional and provincial due to the importance of historic resource information. • Secondary impacts, which could adversely affect historical resources, include the unauthorized collection of specimens by non-archaeologists, and unregulated vehicular activity. Such potential adverse secondary impacts will be managed by restricting access to the Solv-Ex site by unauthorized individuals. The impact should be Low in magnitude, Negative and Long-term in duration (other impact terms are not applicable). • Bitumount is a provincially designated Historic Site. Solv-Ex development activities may visually impact the site, particularly in light of potential development of the site for tourism purposes. This impact is Negative, Moderate-term in duration and Irreversible during the life of the project (other impact terms are not applicable). • Positive effects from the HRIA and mitigation activities to historic and prehistoric and monitoring of paleontological finds will contribute to the scientific database and understanding of the history and prehistory of the region. This impact is considered Long-term in duration (other impact terms are not applicable). **Post-Operation:** • None.

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

F. SOCIO-ECONOMIC RESOURCES

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Regional Labour Force Employment	• Maximize local and regional employment opportunities through planning and ongoing consultation with Canada Employment Centre and local Aboriginal employment/economic development officers.	**Life of Operation:** • There will be approximately 350 oil sands operations and maintenance positions available at the Solv-Ex facility north of Ft. McKay (Impact - high/positive/Ft. McKay) (Impact - low/positive/Ft. McMurray) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - moderate/negative/Ft. McKay) (Impact - low/negative/Ft. McMurray) (Impact - low/neutral/regional)
2. Changes in Regional Population	• Minimize local and population effects through use of on-site accommodations for construction and operations personnel.	**Life of Operation:** • It is estimated that the net population effect on Ft. McMurray during Solv-Ex operations is an increase of 400-500 persons (Impact - low/positive/Ft. McMurray) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/negative/Ft. McMurray) (Impact - low/neutral/regional)
3. Changes in Regional Business Opportunities	• Maximize local and regional business opportunities through award of supply/service contracts to Fort McKay, Fort McMurray and local Aboriginal companies.	**Life of Operation:** • Solv-Ex annual purchases during operations are estimated to be substantial (Impact - high/positive/Fort McKay) (Impact - moderate/positive/Fort McMurray) (Impact - minor/positive/regional) **Post-Operation:** • (Impact - moderate/negative/Fort McKay) (Impact - low/negative/Fort McMurray) (Impact - low/neutral/regional)

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

F. SOCIO-ECONOMIC RESOURCES (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
4. Changes in Regional Labour Force Training	• Maximize local and regional training opportunities through planning and ongoing consultation with Keyano College, Canada Employment Centre and local Aboriginal employment/ economic development officers.	**Life of Operation:** • Solv-Ex will work closely with Keyano College and other oil sands operators to identify and implement specific training needs, especially for local Aboriginals (Impact - moderate/positive/Ft. McKay) (Impact - low/positive/regional) **Post-Operation:** • (Impact - low/negative/Ft. McKay) (Impact - low/neutral/regional)
5. Changes in Regional Infrastructure	• Minimize local and regional infrastructure effects through use of existing facilities and construction of on-site permanent staff accommodations.	**Life of Operation:** • The use of an on-site camp for more than 50% of the operations worker accommodations will have low impact on regional infrastructure. Some available housing stock will be used in Ft. McMurray (Impact - low/neutral/regional) (Impact - moderate/positive/Ft. McMurray) **Post-Operation:** • (Impact - low/neutral/regional) (Impact - low/negative/Ft. McMurray)
6. Changes in Regional Transportation	• Minimize local and regional transportation effects through use of existing highway transportation network and utility corridors and upgrading of road network north of Ft. McKay to Solv-Ex site.	**Life of Operation:** • Increased traffic on Highway 63 and extension of daily highway use north of Ft. McKay to Solv-Ex site (Impact - moderate/negative/Ft. McKay) (Impact - low/negative/Ft. McMurray) **Post-Operation:** • (Impact - moderate/positive/Ft. McKay) (Impact - low/neutral/Ft. McMurray)

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

F. SOCIO-ECONOMIC RESOURCES (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
7. Changes in Regional Education - Primary and Secondary	• Minimize impacts on local and regional schools through on-site accommodations of personnel and planning and ongoing consultation with school superintendents.	**Life of Operation:** • Current over-capacity situation in Ft. McMurray school system (Impact - low/positive/Ft. McMurray) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/negative/Ft. McMurray) (Impact - low/neutral/regional)
8. Changes in Regional Education - Post-Secondary	• Maximize use of available job training resources at Canada Employment Centre and Keyano College for upgrading capabilities of local Aboriginals	**Life of Operation:** • Training for Solv-Ex operations and maintenance positions easily accommodated at Keyano College (Impact - low/positive/regional) **Post-Operation:** • (Impact - low/negative/regional)
9. Changes in Regional Public Health	• Minimize impacts on local and regional health and medical services through participation in regional Mutual Aid Program and ongoing consultation with local and regional health authorities	**Life of Operation:** • Health and medical requirements are easily accommodated within existing hospital and nursing station facilities (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/neutral/regional)
10. Changes in Regional Socio-Cultural Conditions	• Minimize impacts on Aboriginal communities through worker orientation/ cross-cultural programs and ongoing consultation with local Aboriginal community leaders	**Life of Operation:** • Oil sands projects are not new to Aboriginal communities in the study area but do bring change in lifestyle from traditional to industrial socio-economy (Impact - low/negative/Ft. McKay) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/neutral/Ft. McKay) (Impact - low/neutral/regional)

Table 2. Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Concluded).

F. SOCIO-ECONOMIC RESOURCES (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
11. Changes in Regional Substance-Abuse	• Minimize impacts on communities through worker orientation and ongoing consultation with community leaders, health authorities and law enforcement officials	**Life of Operation:** • Increase wage incomes in communities will likely lead to increase in consumption of alcohol and/or illegal drugs (Impact - moderate/negative/regional) **Post-Operation:** • (Impact - low/neutral/regional)
12. Changes in Regional Law Enforcement	• Minimize impacts on communities through worker orientation and ongoing consultation with law enforcement officials	**Life of Operation:** • Increase in wage incomes will likely lead to some increase in petty theft or impaired driving charges (Impact - low/negative/regional) **Post-Operation:** • (Impact - low/neutral/regional)

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1.0 INTRODUCTION AND PROJECT OVERVIEW

Solv-Ex Corporation is applying to the Alberta Energy and Utility Board (AEUB) for a seven year approval to construct and operate an experimental oil sands co-production facility from November 1995 to October 2002. The facility will be used to evaluate the feasibility of a new co-production technology for the production of Pipelineable Crude Oil (PCO) from the Athabasca oil sands and minerals from fine clay also found in the McMurray Formation. Production levels will be 1674 cubic metres per stream day (m^3/sd) of PCO, 64 000 metric tonnes per year (t/y) of alumina, 12 000 t/y of potassium sulphate and 14 000 t/y of ferrous sulphate.

The site for the proposed mine and plant is Solv-Ex owned Lease 7276120T05 (herein called Lease 5) located 85 km north of Fort McMurray and 20 km north of Fort McKay (Figure 1.1).

1.1 Company Profile and History

The Solv-Ex Corporation was established in 1980 with the objective of developing, designing, constructing and operating an oil sands processing facility using proprietary technologies. The facility was designed to incorporate an integrated process concept that is environmentally acceptable, and that is profitably operated in plant production module sizes smaller than those of current and recently planned synthetic crude oil plants.

The applicant is a United States public corporation listed on the NASDQ exchange and is registered under the Alberta Business Corporation Act as a non-resident corporation. Solv-Ex has entered into a joint financial venture with United Tri-Star Resources Ltd. which is a registered Calgary-based Alberta corporation. The proposed Oil Sand/Mineral Processing project will be managed and operated by Solv-Ex Corporation. Currently the share ownership of the facility is:

- Solv-Ex Corporation 90%
- United Tri-Star Resources Ltd. 10%

The corporate history of pursuing this objective is as follows:

- 1980-1988: A Research Laboratory and Pilot Plant with a processing capacity of 2 t/h (for bitumen extraction and tailings processing from oil sands/shales) was established in Albuquerque, New Mexico. Laboratory and pilot work was focused on solvent extraction processes. More than 1000 t of oil sands were processed in the Pilot Plant, including research tests conducted for AOSTRA and Shell Canada Ltd.

- 1988-1994: Development of a hot water based bitumen extraction process (no caustic addition) and of the mineral extraction process was initiated at the Research Laboratory and Pilot Plant. Lease 5 was acquired from Can-Amera Oil Sand Development Limited. An additional 200 t of Lease 5 oil sands were processed for bitumen extraction and 25 t of clay tailings were processed for mineral extraction in the Pilot Plant.

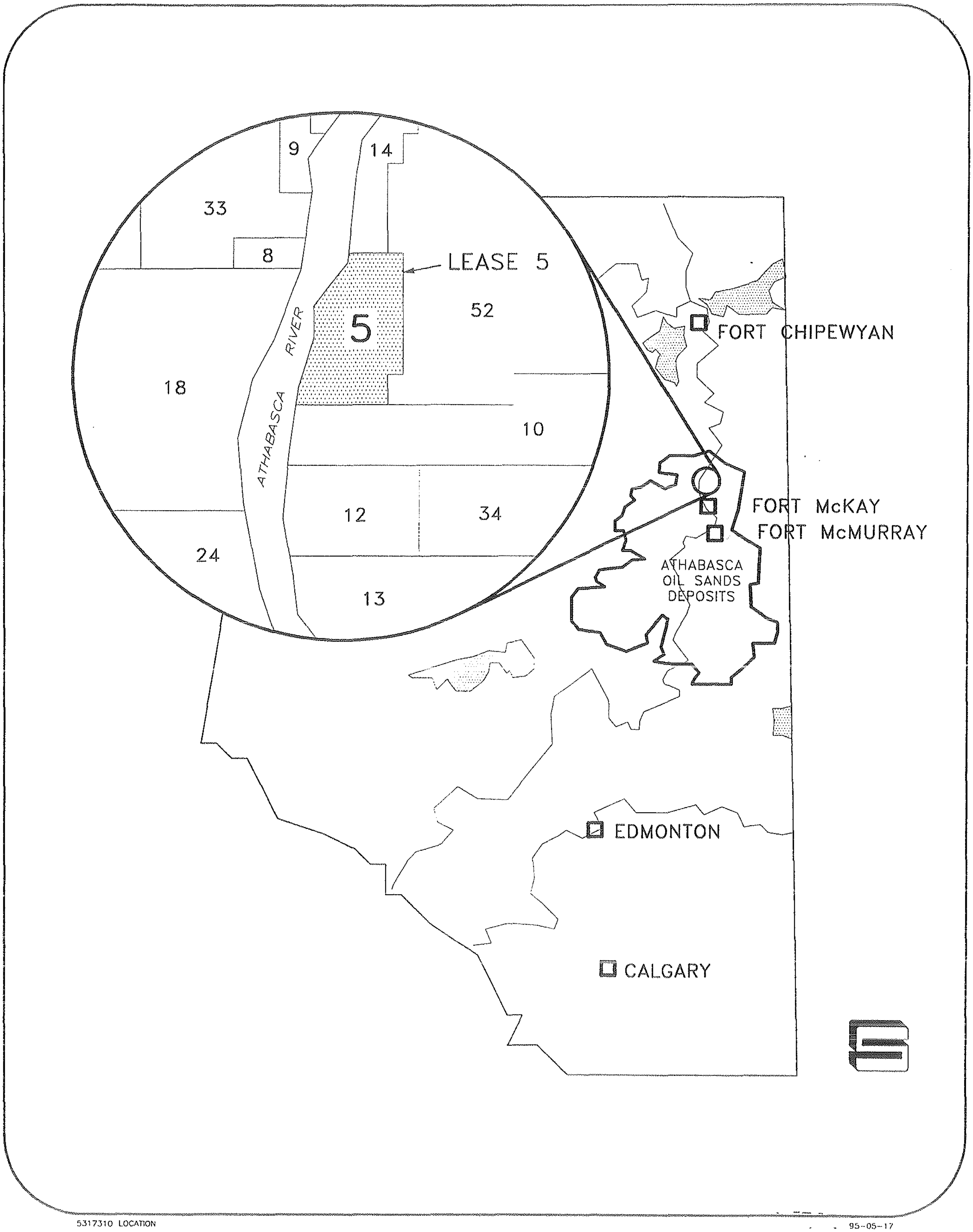


FIGURE 1.1 PROJECT LOCATION

- 1994: A joint venture with United Tri-Star Resources Ltd. was established to develop Lease 5. A comprehensive feasibility study was undertaken to build, operate and test a large scale, experimental co-production plant for the production of PCO, alumina, potassium sulphate and ferrous sulphate.

The name and address of the head office of the Applicant is:

Solv-Ex Corporation
#300, 500 Marquette Blvd.
Albuquerque, New Mexico
U.S.A., 87102

Attention:	Mr. Herb Campbell Senior Vice President
Phone:	(505) 243-7701
Fax:	(505) 243-7705

The address of the Calgary office of the Applicant is:

Solv-Ex Corporation
Suite 705, 101 - 6th Avenue S.W.
Calgary, Alberta
T2P 3P4

Attention:	Mr. Aldo Corti
Phone:	(403) 233-9254
Fax:	(403) 233-8932

1.2 Project Components and Development Schedule

The Solv-Ex Project is comprised of the following components:

- A total of 331 ha of land will be disturbed for Solv-Ex facilities including 296 ha within Lease 5 and 35 ha within the 90 m wide utilities corridor for the road upgrade and gas pipeline (Figures 2.3 and 2.8 illustrate vegetation clearing boundaries for the plant/mine facilities and the utility corridor, respectively).

- A 50 ha surface mine that will provide bitumen for six years, and be mined with front shovel excavators on several benches and hauling trucks.

- A 50 ha external mine waste dump area for storage for gravel resources, overburden and central reject from the mine and oversized rock rejects from the bitumen extraction facilities.

- A 42 ha plant site for the extraction and upgrading of bitumen to PCO and the extraction of minerals (aluminum oxide, ferrous sulfate and potassium sulfate) from fine clay tailings. Bitumen extraction will use a hot water process (without caustic addition or solvent), bitumen upgrading will use a soaker visbreaking process and mineral extraction will use sulphuric acid leaching, salt crystallization and calcining processes. The plant site will support facilities for the conventional amine contacting and Claus processes for fuel gas sweetening and sulphur recovery for sulphuric acid manufacturing, steam and electricity generation, water treatment, water and muskeg storage sites, and the office facilities and construction/operation camp.

- A 100 ha dyked disposal area for storage of dry tailings (primarily sand with some silt) from the bitumen and mineral extraction processes. Water will be removed from the dyked area and recycled to the bitumen extraction facilities for reuse in slurrying. Excess clay cake produced in bitumen extraction and not required in mineral extraction will be disposed by truck to the tailings disposal area.

- Utilities or resources required to support the mine and plant site are outlined below:

  - Energy sources will be fuel gas (generated in the upgrading process), and natural gas or diesel fuel. Natural gas could be supplied by a pipeline from the southern boundary of Lease 13, while diesel fuel would be trucked to the site.

  - Electrical power during construction will be provided through a diesel powered electrical generator. Electric power during operations will be generated by gas turbines. Steam for process heating and utilities will be generated in the utility building by steam generators fuelled with natural gas or diesel fuel.

  - Make-up water to meet plant requirements will be obtained from the Athabasca River through a shore-based water intake structure and pumped to the plant site through a pipeline (layout in Figure 2.1). The area to be disturbed for the water intake and pipeline is 2.5 ha. Water may be filtered through the water treatment plant before being used in plant processes.

  - Low level waste heat throughout the plant will be dissipated using a closed loop recirculating coolant system.

  - Utility and instrument air will be provided through compressors.

  - Nitrogen will be either produced on-site through a gaseous generation facility, or trucked to site in liquid form.

- Gravel will be provided from the existing Alberta Transportation and Utilities gravel pit south of the proposed plant site.

- Elemental sulphur will be purchased from outside suppliers, once the sulphur block inventory has been consumed, and trucked in molten state to the plant.

- Management of other wastes and by-products will involve:

  - Waste water recycling will be maximized. However, some waste water (sanitary waste, surface drainage and potentially saline aquifer water) will be discharged to the Athabasca River through the shore-based water outlet structure. All waste water will be treated to meet Surface Water Quality Objectives (SWQO) of AEP before being discharged.

  - Garbage will be compacted and transported by truck to an AEP approved landfill. Over the longer term, Solv-Ex may make a separate application under AEPEA for an on-site industrial landfill.

  - By-product pitch will be stored as blocks on clay-lined or concrete/asphalt ground pads within the plant site for possible future use as fuel or in a higher conversion upgrading technology. By-product elemental sulphur will be stored as blocks within the plant site on clay-lined or concrete/asphalt ground pads and used in the mineral extraction process. Surface and subsurface drainage from these two storage sites will be collected and routed to the lined surface drainage retention pond. It will be released to the plant perimeter ditch if it meets AEP requirement (SWQO), or directed to the process water make-up system.

- A utility corridor that will support an upgraded access road, and a natural gas pipeline, both of which will be constructed and operated by proponents other than Solv-Ex. Access to the proposed project site will be provided by building a road within the existing, cleared right-of-way for Highway 63.

- Transportation of materials will include:

  - PCO and mineral products will be trucked from Lease 5 to markets (Section 9.5.1)

  - Diesel fuel, molten sulphur and chemicals will be trucked to Lease 5.

  - There are no airstrips, or boat launches/landings associated with the Solv-Ex project.

- A construction work force of up to 350 people and an operations work force of up to 350 will be required. A construction camp housing up to 250 people will be built within the plant site (Figure 2.13).

The proposed Phases of Development of Solv-Ex's Co-production Experimental Project are outlined in Figure 1.2. Construction and operation of the co-production experimental project will have four stages that are discussed as Phase I and Phase II:

- Site Preparation Phase will include plant site development activities between July 1 and October 31, 1995 (e.g., clearing vegetation, removing muskeg and gravelling plant site, and upgrading the access road), environmental monitoring for baseline information and a drilling program for geotechnical data.

- Development of the mine from the first quarter to fourth quarter, 1996 and oil sand mining from the fourth quarter 1996 to October 2002 (Phase I).

- Construction of bitumen extraction and upgrading plant from October 1995 to October 1996, and operation from November 1996 to October 2002 (Phase I).

- Construction of the mineral extraction plant from July 1996 to July 1997, and operation from July 1997 to October 2002 (Phase II).

After 5 years of experimental operation of the mineral extraction plant (July 2002), should results confirm expectations, an Application will be submitted to the AEUB and other government departments for approvals for a commercial scheme. If the commercial project does not proceed, the site of the co-production experimental project will be decommissioned, reclaimed and abandoned (upon receipt of the reclamation certificate). Reclamation of the mined-out areas will begin in 1998 or earlier depending upon the results of detailed mine planning.

The Development Schedule for Solv-Ex's Co-production Experimental Project is illustrated in Figure 1.2. The milestone development dates are:

- Submit Application for Solv-Ex Co-production Experimental Project (including Alberta Energy and Utility Board (AEUB) Application, Environmental Impact Assessment and AEP Environmental Operating Approval) in June, 1995.

- Acquire Miscellaneous Lease (MLL) and Oil Sand Exploration Approval by July, 1995.

- Acquire AEUB Approvals under the Oil Sand Conservation Act by October, 1995.

- Initiate site activities of clearing and grading the plant site, July 1995.

CO-PRODUCTION EXPERIMENTAL FACILITY
SOLV-EX CORPORATION

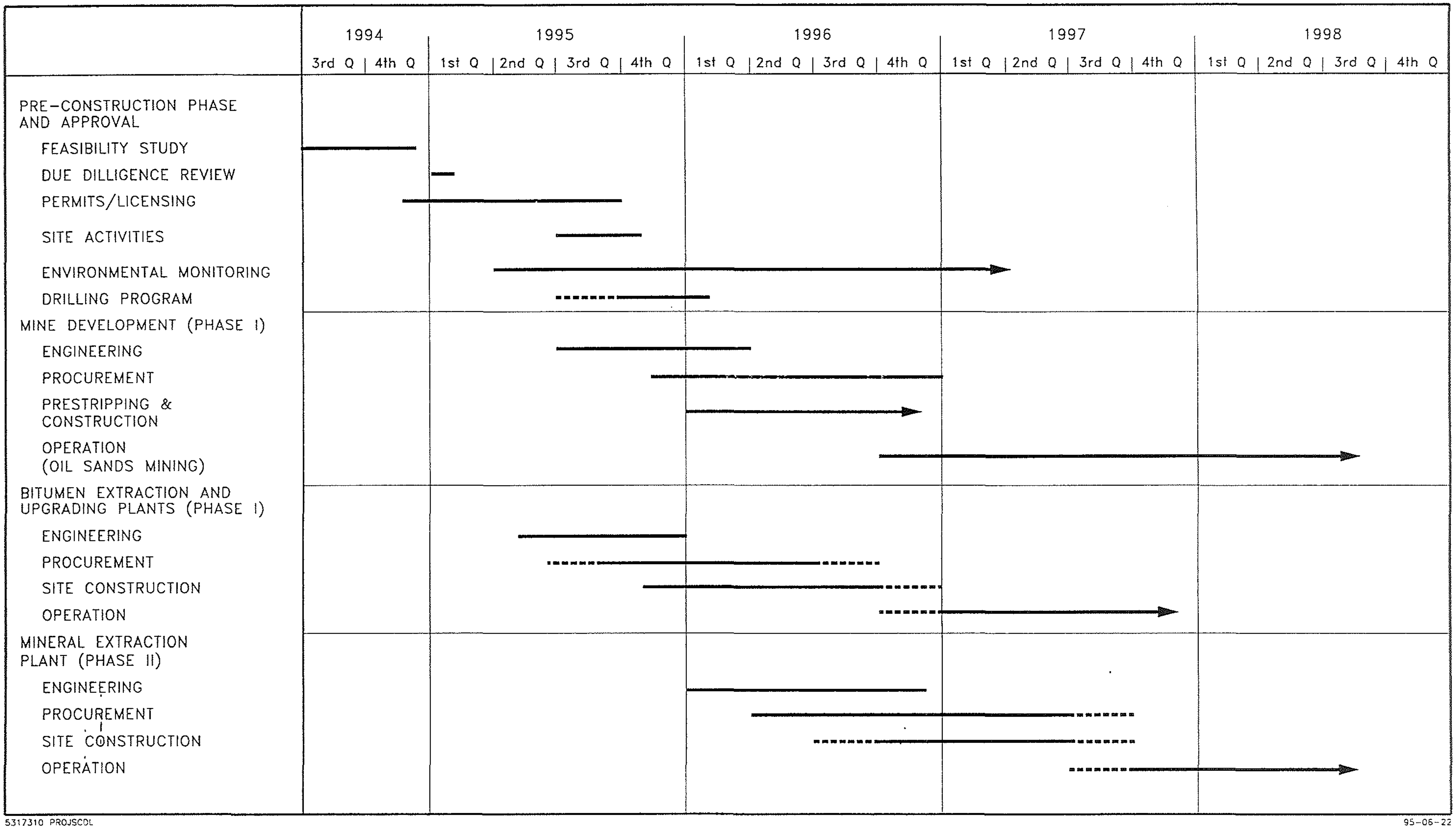


FIGURE 1.2 PROJECT SCHEDULE

- Complete construction of bitumen extraction and upgrading plant and begin operation in November 1996.

- Complete construction of mineral extraction plant and begin operation in July 1997.

- An AEUB Approval extending to 2002 will provide the required time (5 years) to test and optimize the combined processing technologies.

1.3 Project Need and Alternatives

The principal need of the project is to complete an experimental program and assess the sustained feasibility and reliability of the co-production bitumen and mineral extraction technology on a large scale over a period of 5 years.

Pilot plant operations and technology developments since 1980 have led to a co-production technology that has the potential to offer, at a commercial scale, several technical, economic and environmental features desirable to the oil sands processing industry:

- Extraction of bitumen and clay fines from the oil sands without caustic and solvent, and without the bitumen extraction by-product of wet tailings requiring large tailings ponds for water clarification;

- Hot water extraction of bitumen from the oil sands without caustic, and with the by-products of coarse sand and silt which are amenable to easy hydraulic transportation and backfilling in mined-out pit areas;

- Bitumen extraction with reduced energy consumption as significant amounts of hot water are recycled internally within the extraction process to reduce steam and hot water heating requirements.

- Sulphuric acid leaching of clay minerals, with total recirculation of liquid stream and selective crystallization to produce solid mineral products of qualities and purities equal to or better than those of current supplies to the aluminum metal production, fertilizer blending and other specialty mineral industries;

- Metals extraction without producing liquid tailings but with the by-products of neutralized, washed and dewatered high silica tailings;

- Closed water loops for the bitumen and mineral extraction processes which conserve energy (for water heating due to internal recycling of hot water in bitumen extraction) and water resources; and

- Production of a Pipelineable Crude Oil (PCO) with a lower API gravity (23°) than synthetic crude oil (at 32° API gravity) by using a thermal visbreaking technology (soaker visbreaking process) that does not utilize hydrogenation.

These technology features were analyzed in a major engineering, economic and market assessment study completed during 1994. The conclusion of the study was that a plant scale of 1674 m^3 PCO per stream day (m^3/sd) would be appropriate to test the processes for an initial period of 5 to 7 years.

Oil Sand Lease 5 was acquired from Can-Amera Oil Sand Development Limited by Solv-Ex in 1990. This is the corporation's only oil sand lease in the region, and was thus designated as the location for the co-production experimental project upgrading unit. The development represents a research project, not a commercial sized oil sands development, and will span a time frame of seven years.

Two alternative mine locations are presented in Figure 2.6. The location of the mine is dependent on the spatial extent and quality of the oil sands ore body, and on the depth of overburden. There are few potential alternative locations for the mine site, as the depth to oil sand would significantly increase overburden stripping costs, and possibly jeopardize the economic viability of the short-term project. The preferred mine location is situated in the northwest section of Lease 5, southeast of the Bitumount Historic site and adjacent to the Athabasca River (Figure 2.6; Alternative A). To reduce the effects of the mine on the Athabasca River valley, an alternative mine configuration has been presented (Figure 2.3; Alternative B). The assessment of impacts associated with the mine have been defined based on the location of Alternative A.

The land within Lease 5 has been extensively disturbed by previous oil sand mining activities, as is summarized in Section 1.5. Therefore, to minimize the disturbance to the land base, both mine alternatives A and B have been sited to encompass the area previously disturbed by oil sand mining.

1.4 Setbacks

The November 1994 Draft publication *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan* (IRP) (Alberta Environmental Protection 1994) outlines the Government of Alberta's resource management policy for public lands in the area. The IRP is still in a draft stage and does not represent a regulatory requirement. However, it does represent Government Policy that has been developed based on discussions with key stakeholders in the region.

The proposed Solv-Ex co-production project lies within the Athabasca-Clearwater and Mildred-Kearl Lakes Resource Management Areas (RMA), two of five RMAs designated in the IRP.

The mine and a portion of the utility corridor cross the Athabasca-Clearwater RMA (Figure 4.33). The IRP states that, within this RMA, exploration and development of oil sand resources in the

Athabasca River Valley will be considered only if the proponent can demonstrate that mitigation of impacts on the resources and values identified below can be achieved:

- Wildlife: protect vegetation (wind shelter, ungulate wintering areas, travel corridors), riparian habitat, and habitat diversity.

- Erosion: protect sensitive soils and drainage patterns from erosion or disturbance, and downstream users from sedimentation.

- Floodplain: setback to at least 1:100 year flood level and accommodate for natural evolution in the path of the river.

- Water Quality: protect water quality for downstream user including human, fish and other biota, and natural surface and groundwater regimes.

- Recreation and Tourism: protect visual and acoustic aesthetics for river users and recreationists using the river as a travel corridor, and protect characteristic valley horizon.

- Ecological: protect unique physical river valley characteristics (e.g., springs), rare flora and fauna, and critical ecological functions and processes.

- Traditional Lands: protect important traditional land use sites for First Nation Peoples.

- Historic Sites: protect historic resources for scientific, educational and interpretive purposes.

Solv-Ex is making application for approval for the preferred location for the mine (Alternative A; Figure 2.6), where the proposed setback of the mine from the Athabasca River ranges from 50 to 100 m. Field programs that have been conducted in the Athabasca River valley in the vicinity of the proposed mine include: wildlife ungulate aerial and track counts (February 1995), rare plant inventory (June 1995), tree coring (June 1995) and, ground-truthing the vegetation and soil maps (June 1995). These programs indicate that:

- There is no defined valley break in the vicinity of the proposed development,
- No islands in the Athabasca River will be affected by the development,
- There are no rare plants,
- There is no important ungulate wintering, or critical habitat areas,
- There is no old growth forest, although a narrow band (maximum of 50 m wide) of white spruce, some > 150 years of age, were identified below the river escarpment. None of these trees will be affected by the mine development, and
- There are no unique soils.

Further field investigations of the location will be pursued by Solv-Ex in 1995:

- Drilling to determine the geotechnical stability of the Athabasca River bank,
- Survey for "springs",
- Rare animal inventory,
- Pellet group and browse inventory to determine ungulate use of area, and
- Historical resource inventory.

Information on traditional use of lands by the people of Fort McKay in the vicinity of the proposed Solv-Ex development was compiled by Fort McKay Environmental Services (1995; Appendix VIII). This publication "Information Report for Solv-Ex Cumulative Effects Study" was prepared in April 1995, and provides information on furbearer trapping; big game, game bird, fish and berry harvesting sites; trees and plant used for cultural and medicinal use; cabins and trails; and spiritual, sacred burial sites.

Information from these programs will be presented to Alberta Environmental Protection so that the setback of the Solv-Ex mine from the Athabasca River and the locations for the other facilities can be finalized. Within the Athabasca-Clearwater RMA, it is suggested that the setback for surface mining of oil sands in the vicinity of the Athabasca River be defined as:

- The valley break plus 100 m or 1 km from the river's edge which ever is less or,
- Highway 63 (if it is closer than 1 km).

As of the date of filing of this EIA, members of the public have not identified the setback of the mine from the Athabasca River as an issue.

1.5 Project History and Regulatory Approval

Lease 5 has a long development history as it was where the original oil sands deposits were discovered by Peter Pond. The following chronology outlines some of the development history of the site:

- 1778 — Peter Pond, a fur trader, while travelling down the Athabasca River, describes bitumen oozing out of the ground in the vicinity of Lease 5.

- 1938 — The Lease, owned by Robert C. Fitzsimmons, produces 2500 barrels of asphalt and 2500 barrels of fuel oil.

- 1954 — Henry Ford and Eugene Du Pont purchased Lease 5 and formed the company Can-Amera.

- 1956 Arthur Little and Foster Wheeler constructed and operated a test plant for the Coulson process which successfully produced thousands of tons of oil from Lease 5.

- 1961 Royalite (The Syncrude Group) acquired an option on Lease 5 and estimated there were 250 million barrels of recoverable bitumen.

- 1986 Can-Amera, now a company owned 70% by McMillan Ring Free, commissions a drilling program for a small mining development to produce 15 000 BPD bitumen.

- 1988 Solv-Ex takes an option on Lease 5 from Can-Amera to evaluate the resources and a 10 000 BPD oil facility on the lease.

- 1989 A feasibility study for a 10 000 BPD facility completed and Dr. S.G. Pemberton of the University of Alberta estimated the resource at about 1.4 billion barrels in place.

- 1990 Solv-Ex acquired Lease 5 from Can-Amera.

- 1994/95 Solv-Ex confirms the technical and economic feasibility of Co-Production of oil and alumina from Lease 5 oil sands.

The area disturbed by past exploration and mining in Lease 5 covers 16 ha. Other disturbances within Lease 5 cover an area of 165 ha and include: the Alberta Forest Service airstrip, Canstar exploration camp, a gravel pit, well sites and cutlines, and the right-of-way for Highway 63.

The Federal, Provincial and Municipal legislation under which Solv-Ex will require Approvals or Licenses for construction and operation of their plant facilities and mine are outlined below. Approvals for the natural gas pipeline, transmission line and upgraded access road will be obtained by the proponents of these facilities.

- **Alberta Oil Sands Conservation Act (OSCA)** which addresses the requirements for Approvals for oil sand development.

    - An Approval issued by the Alberta Energy and Utilities Board (AEUB) is required to construct and operate the experimental co-production plant with its associated tailings disposal area and to develop the surface mine with its associated waste dump area. The AEUB requires an approval of the EIA by Alberta Environmental Protection (AEP). There are no Canadian Environmental Assessment Act triggers that would involve the Federal government in the EIA process. However, Solv-Ex is aware that several Federal departments are interested in the Solv-Ex project, and will keep these departments informed on the project.

- Well Licences for drilling to delineate the ore body is required from AEUB.

- **Alberta Environmental Protection and Enhancement Act (AEPEA) and Regulations** which addresses the requirements for an Environmental Impact Assessment, and Environmental Approvals.

    - An Oil Sands Exploration Approval issued by AEP is required for ore body delineation.

    - An Environmental Operating Approval (EOA) issued by AEP is required. The EOA will address activities that could adversely effect the environment including the release of substances to the air or water, waste management, and conservation and reclamation. Approvals will include the Conservation and Reclamation Approval and Reclamation Certificate.

    - Reclamation Certificate issued under AEPEA will be required after the project area is reclaimed, and before responsibility for the land is reverted back to the Crown.

- **Alberta Public Lands Act and Regulations** which address the administration of public lands and the disposition of lands through permits and leases. They also address the accumulation of waste, soil erosion, damage to watersheds capacity and weed invasion.

    - A Miscellaneous Lease (MLL) issued by AEP is required for clearing, grading and gravelling of the plant site and construction of the access road. In addition, Licenses of Occupation and Pipeline Agreements may be required under the Act for linear developments, such as pipeline rights-of-way.

    - A Mineral Surface Lease (MSL) issued by AEP for clearing and developing the mine.

- **Alberta Forest and Prairie Protection Act and Regulations** that addresses fire prevention and the clean-up of oil spills.

    - A Burning Permit issued by AEP is required for burning of debris and slash etc.

- **Alberta Historical Resources Act** which addresses the surveying, recording and protection of historical resources. An Historic Resource Impact Assessment (HRIA) will be prepared to identify and present a management protection plan for historic resources.

    - A Historical Resource Permit issued by Alberta Community Development is required prior to site disturbance.

- **Alberta Water Resources Act and Regulations** deals with issues related to withdrawal or alternation of use or flows of waterbodies and use of groundwater for all purposes other than domestic.

    - An Interim Licence issued by AEP is required to divert and use water from the Athabasca River for industrial purposes.

    - A Drainage Licence issued by AEP to dispose of site drainage to natural drainage systems such as the Athabasca River is required.

- **Alberta Forests Act** (Timber Management Regulation) which requires the minimization of soil erosion, avoidance of pollution of water and salvage of timber during clearing of land.

    - A Permit issued by AEP is required for site clearing and timber harvest.

- **Alberta Pipeline Act** which deals with the construction and operation of all pipelines in the province.

    - A Permit to Construct and Licence to Operate issued by AEUB is required prior to development of the water pipeline.

- **Alberta Planning Act** which addresses land use designations and conditions for development.

    - A Development Permit issued by the Municipality of Wood Buffalo is required.

- **Alberta Safety Codes Act** which addresses structural and mechanical requirements of buildings.

    - A Building Permit issued by Alberta Labour is required; or

    - Accredited corporation status from the Safety Codes Council under Section 24 of the Act.

1.6 Nature and Scope of the Environmental Impact Assessment

The Environmental Impact Assessment for the Solv-Ex Project has been structured using the following approach:

- Provide a Description of the Experimental Co-production Project including the mine, plant site and associated linear infrastructures, and the management systems to protect air, water and land resources and public safety (Section 2.0),

- Outline the Public Participation and Consultation program implemented by Solv-Ex Corporation (Section 3.0),

- Describe the existing biophysical resources and resource use in the Local and/or Regional Study Areas, including background air quality and noise, terrain and geology, soils, surface water, hydrogeology and groundwater, vegetation, wildlife resources, fisheries and aquatic resources, and resource use including both consumptive and non-consumptive uses (Section 4.0),

- Identify the potential impacts of the proposed project on these biophysical resources and resource use (Section 5.0),

- Describe the existing historical resources in the Local Study Area (Section 6.0),

- Identify the potential impacts of the proposed project on historical resources (Section 7.0),

- Describe the existing socio-economic conditions (Section 8.0), and

- Identify potential impacts of the proposed project on socio-economic conditions (Section 9.0).

1.6.1 *Temporal and Spatial Boundaries of Study Areas*

The temporal boundary for the Solv-Ex project extends from the construction phase, which is proposed for the fourth quarter of 1995, to the end of the life of the seven year experimental research project in 2002.

Three spatially distinct Study Areas have been used to describe the biophysical and historical resources and impacts to these resources for the Solv-Ex Project:

- The **Local Study Area (LSA)** is shown in Figure 1.3 and the legal description is provided in Appendix I. The boundaries were defined to include all terrestrial and aquatic resources that could be disturbed through development of the Solv-Ex Co-production Experimental Project. The detailed locations of the facilities are shown in Figures 2.3 and 2.8. The LSA includes:

    - Lease 5, which will encompass the plant site, mine site, shore-based water intake structures and associated waste or tailings disposal sites,
    - A 1 km wide utility corridor from Lease 5, south to the junction of the Husky Road. The corridor will encompass an upgraded access road and a natural gas pipeline, and

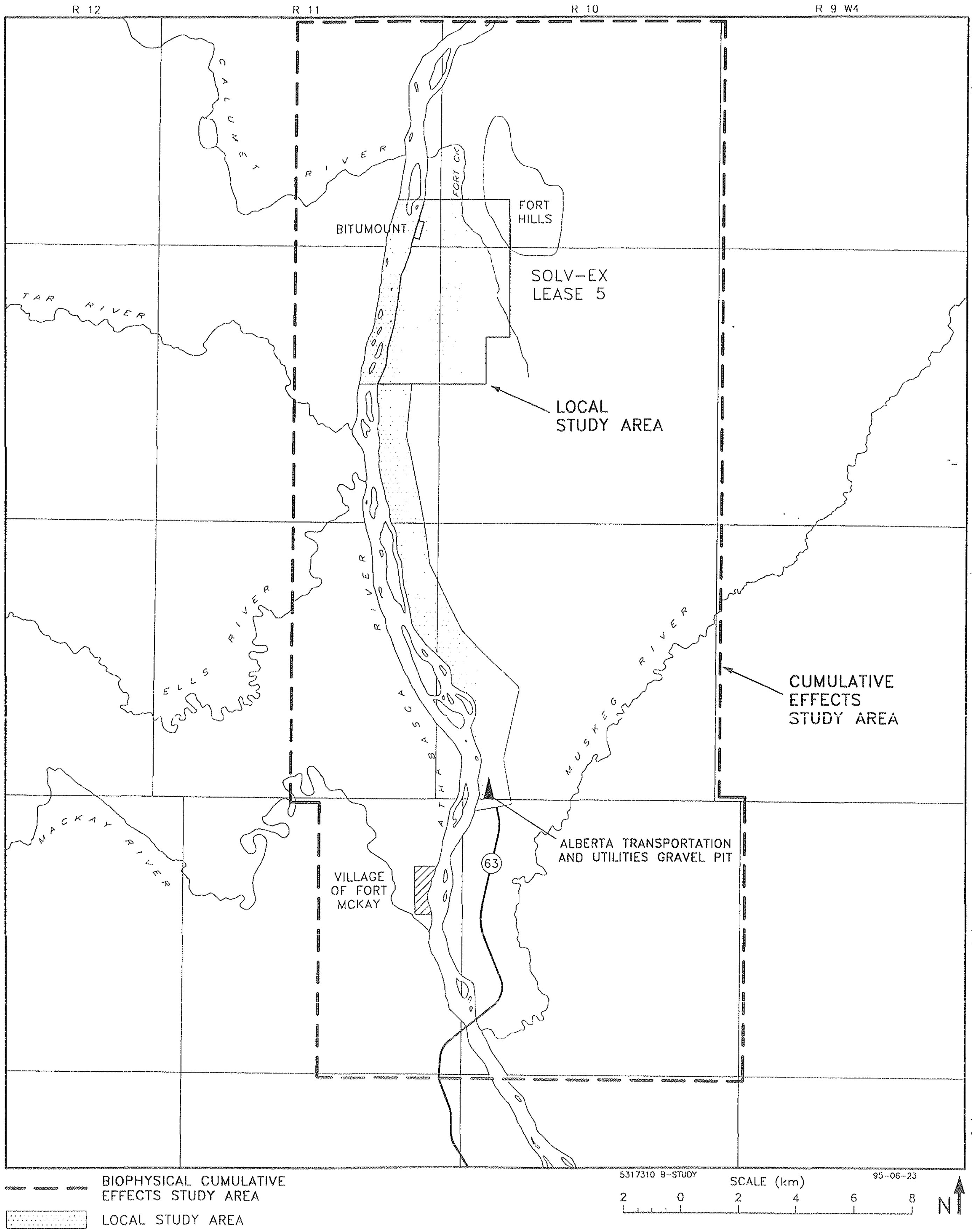


FIGURE 1.3 BIOPHYSICAL CUMULATIVE EFFECTS STUDY AREA (BCESA) AND LOCAL STUDY AREA

- That portion of the Athabasca River immediately adjacent to the Solv-Ex Lease, that will be exposed to potential contamination and water withdrawal as a result of the Solv-Ex operation. The area also contains Lafont Island.

The LSA provides the boundaries for our description of existing terrain, geology, soils, vegetation, historic resources and resource use, focussing on consumptive resource use such as forestry and berry picking.

- The **Biophysical Cumulative Effects Study Area (BCESA)** is shown in Figure 1.3. This larger study area was designed to address cumulative effects from other developments, in addition to those from the Solv-Ex project, on biophysical resources including surface and groundwater, wildlife, fish in the Athabasca River and resource use. The BCESA was designed specifically to include known important wildlife areas (i.e., confluence of Athabasca River with Fort Creek and the Muskeg River, and Fort Hills) and sites that could support special status plants or unique plant communities. Other existing or proposed developments include the village of Fort McKay; linear developments (e.g., roads, transmission lines and seismic lines); and the proposed Syncrude Aurora Mine site.

  The BCESA provided the boundaries for our description of existing wildlife resources, fisheries and aquatic resources, groundwater and surface water, and resource use focusing on both consumptive and non-consumptive uses.

- **The Air Resources Cumulative Effects Study Area** (ARCESA) is shown in Figure 1.4. This still larger study area is required to evaluate the regional effects of deposition due to Suncor, Syncrude and Solv-Ex SO_2 emissions (ADEPT modelling).

The Study Area for the socio-economic and economic components of the project is necessarily large to encompass potential impacts on Fort McMurray, Fort McKay and Fort Chipewyan.

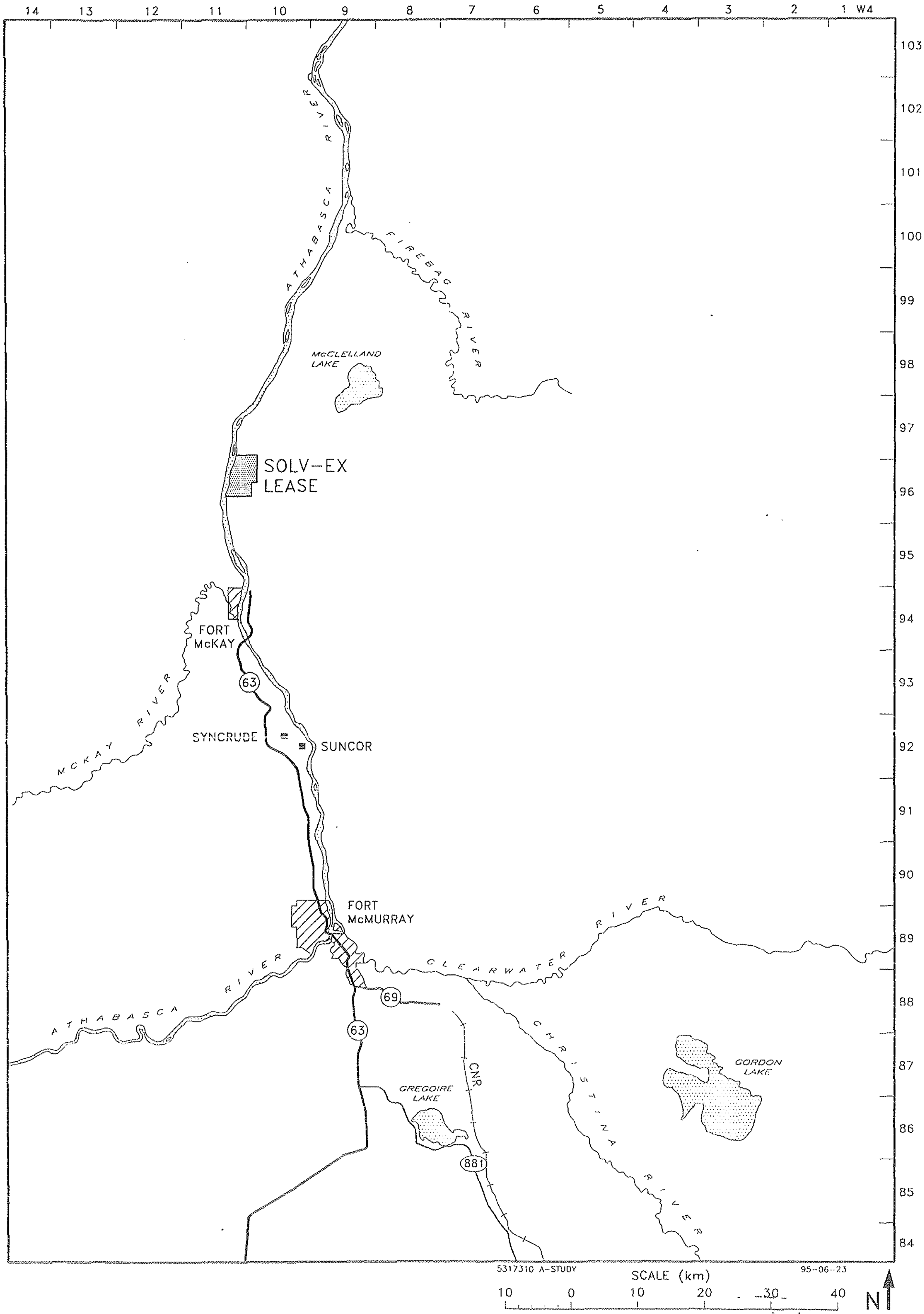


FIGURE 1.4 AIR RESOURCES CUMULATIVE EFFECTS STUDY AREA (ARCESA)

2.0 PROJECT DESCRIPTION

For the purposes of the current Application, the enclosed description covers operations on and around Lease 5 from 1995 to 2002, including the development of the plant, mine, associated ancillary infrastructure (e.g., road) and reclamation plans.

2.1 General Description

Solv-Ex holds Bituminous Oil Sands Lease 5 (also known as Lease 7276120T05, Figure 1.1). Approximately 331 ha of land will be cleared for the experimental project, including 296 ha for the plant, mine and associated facilities and 35 ha within the Utilities Corridor (Table 2.1).

Figure 2.1 shows the location and areal extent of the proposed four major project development areas:

- The mine area which will be developed into a surface mine equipped with shovel excavators and hauling trucks on several benches.

- The external mine waste dump which will provide storage for gravel resources, overburden and central rejects trucked from the mine area and oversize rock rejects trucked from the bitumen extraction facilities.

- The plant site which will be provided with buildings, equipment, storage tanks and structures for the experimental processes of bitumen extraction, bitumen upgrading and mineral extraction and the conventional processes of sulphur recovery, sulphuric acid manufacturing, steam and electricity generation and water treatment.

- The external tailings disposal area which will be developed into a dyked, dry sand disposal area by pumping slurried sand tailings from the bitumen and mineral extraction facilities. The water will be drained from a sand beach and recycled from within the dyked area to the bitumen extraction facilities for reuse in slurrying. Accumulation of clay fines within the dyked area will not occur.

The Site Preparation Phase includes activities planned between July and October 1995, monitoring and surveys for environmental baseline data and a drilling program to obtain geotechnical data and resource data for the proposed mine area. The Site Preparation Phase will be followed by Phase I, which will encompass the development of the mine and the construction and start-up of the bitumen extraction and upgrading facilities. The major site construction work will begin immediately upon receiving the approval for the project. Phase II will encompass the construction and start-up of the mineral extraction plant.

Table 2.1 Area disturbed by Facilities Associated with the Solv-Ex Project.

Mine Area (6 years)		50 ha
External Mine Waste Area		50 ha
Plant Site		42 ha
External Tailings Disposal Area		100 ha
Other Areas Cleared Amongst Facilities		41 ha
Topsoil Storage Areas		3 ha
Other (roads, water pipeline, water intake structure)		10 ha
	Subtotal	296 ha
Utilities Corridor (Proponents other than Solv-Ex)		
- Highway 63 Access Road Upgrade (14 km and 10 m wide)		14 ha
- Natural Gas Pipeline (assumed width of 15 m)		21 ha
	Subtotal	35 ha
TOTAL		331 ha

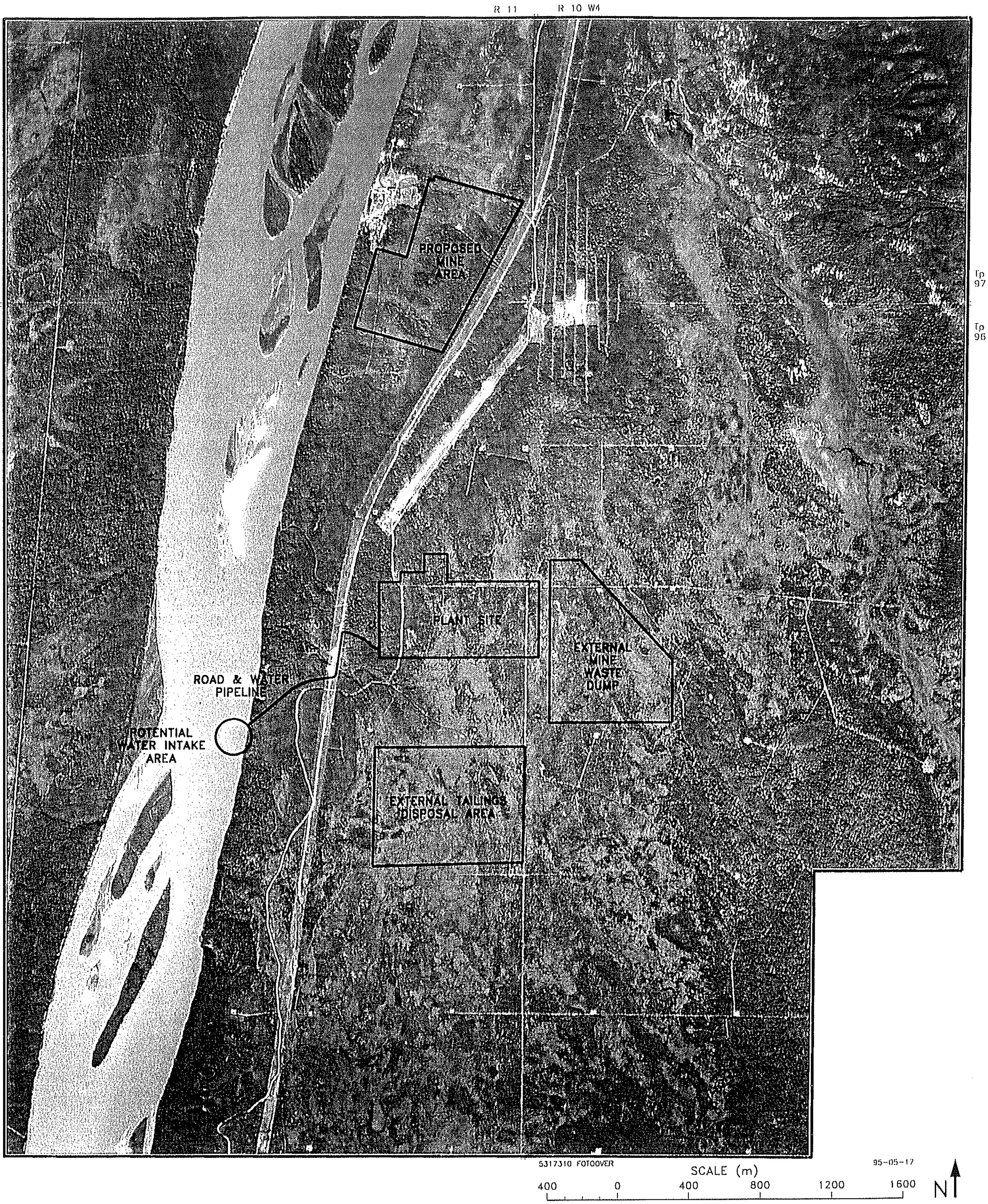


FIGURE 2.1 LAYOUT OF SOLV-EX FACILITIES

Reclamation of mined-out areas will begin during 1998 while tailings disposal in mined-out pit areas may occur before year 2002. The external mine waste dump will serve as a storage site for materials removed from and returned to the mine area during mining and reclamation.

The mine facilities will include overburden and oil sands excavation equipment, truck hauling equipment, an external waste dump area (for muskeg, overburden and oil sands rejects) and an external dry tailings disposal area which will be used until in-pit disposal space is available by the fifth year of mining (Figure 2.1).

The plant facilities will include buildings, processing equipment, storage tanks and structures for the following purposes:

- Bitumen extraction using a proprietary hot water process which does not require caustic addition and use of solvent and which produces relatively dry tailings (mostly sand and some silt) for disposal and a clay cake that is used for mineral extraction.

- Bitumen upgrading by using a soaker visbreaking process to produce pipelineable crude oil (PCO), pitch and sour fuel gas and using conventional amine contacting and Claus processes to sweeten the fuel gas and recover elemental sulphur.

- Mineral extraction by leaching clay fines with sulphuric acid which is produced on-site from elemental sulphur recovered in the upgrading process, elemental sulphur imported to the site and from SO_2 and SO_3 gases recovered within the mineral extraction process.

- Utility supplies of water, demineralized water, steam, electricity, fuel (diesel fuel and natural gas), instrument air, nitrogen.

- The off-site ancillary facilities include: the access road, pipeline for natural gas, and transmission line for power which will be constructed on the existing right-of-way.

- River water intake.

- Waste water management and disposal.

PCO and mineral products will be trucked to markets during the 5 year experimental period. PCO may eventually be pipelined, while mineral products may be eventually shipped by rail.

By-product pitch from the upgrading process will be stored on the plant site. Dry tailings from the bitumen and mineral extraction process will be disposed of in the external tailings storage area.

Water will be pumped from the Athabasca River to the plant to meet the consumptive requirements of the plant personnel and processes. Surface drainage collected from the development areas will be used, when available, to off-set the supply of river water. Process waste water recycling will be maximized within and among the process sections to the extent possible without jeopardizing process chemistry and equipment durability. Biologically treated sanitary sewage and wastewater resulting from raw water treatment will be discharged to the Athabasca River in accordance with requirements of Alberta Environmental Protection (AEP). Saline aquifer water, which may be encountered at the deeper strata of the mine pit may be used for process make-up depending on its salinity and daily amount. Alternatively, it will be treated by dilution with river water to meet AEP requirements and discharged to the Athabasca River.

Plant emissions will be controlled and land surface disturbances will be reclaimed to meet the requirements of Alberta Environmental Protection.

2.1.1 *Land Use and Surface Disposition*

Lease 5 is located on the east side of the Athabasca River, about 36 km north of the existing Syncrude and Suncor plants. The closest community is Fort McKay, located about 20 km south of the lease boundary and on the west side of the river. Highway 63 currently ends about 14 km south of the lease proposed plant site although there is a cleared right-of-way and winter road from the end of the highway to the lease area and beyond. This stretch of the right-of-way was partially upgraded for truck traffic by Solv-Ex during 1994 to allow for the transportation of 500 tonnes of oil sands from the Bitumount Site (Figure 2.1). A land trail criss-crosses this right-of-way along the terrain crests (Figure 2.1). The trail is used by trappers, hunters and fisherman for access during seasonal activities. The trail is not maintained.

The following are located on Lease 5:

- The Bitumount Historical Site is located in the northwest part of the lease area. This site still has the buildings and roads from the oil sands processing facility built during the 1930's and the 1950's.

- An airstrip (owned by the Alberta Environmental Protection) is also located in the lease area.

- Alberta Pacific Forest Industries has a Forest Management Agreement for timber on the lease and surrounding areas.

- Solv-Ex owns the rights to the Mineral Surface Leases (MSL) in the area. An MSL application will be filed to ensure access for the mine along with the C & R application. There are road reservations and gravel deposit reservations within the lease area. Figure 2.2 shows the areas of surface, mineral and oil sands lease rights and reservations.

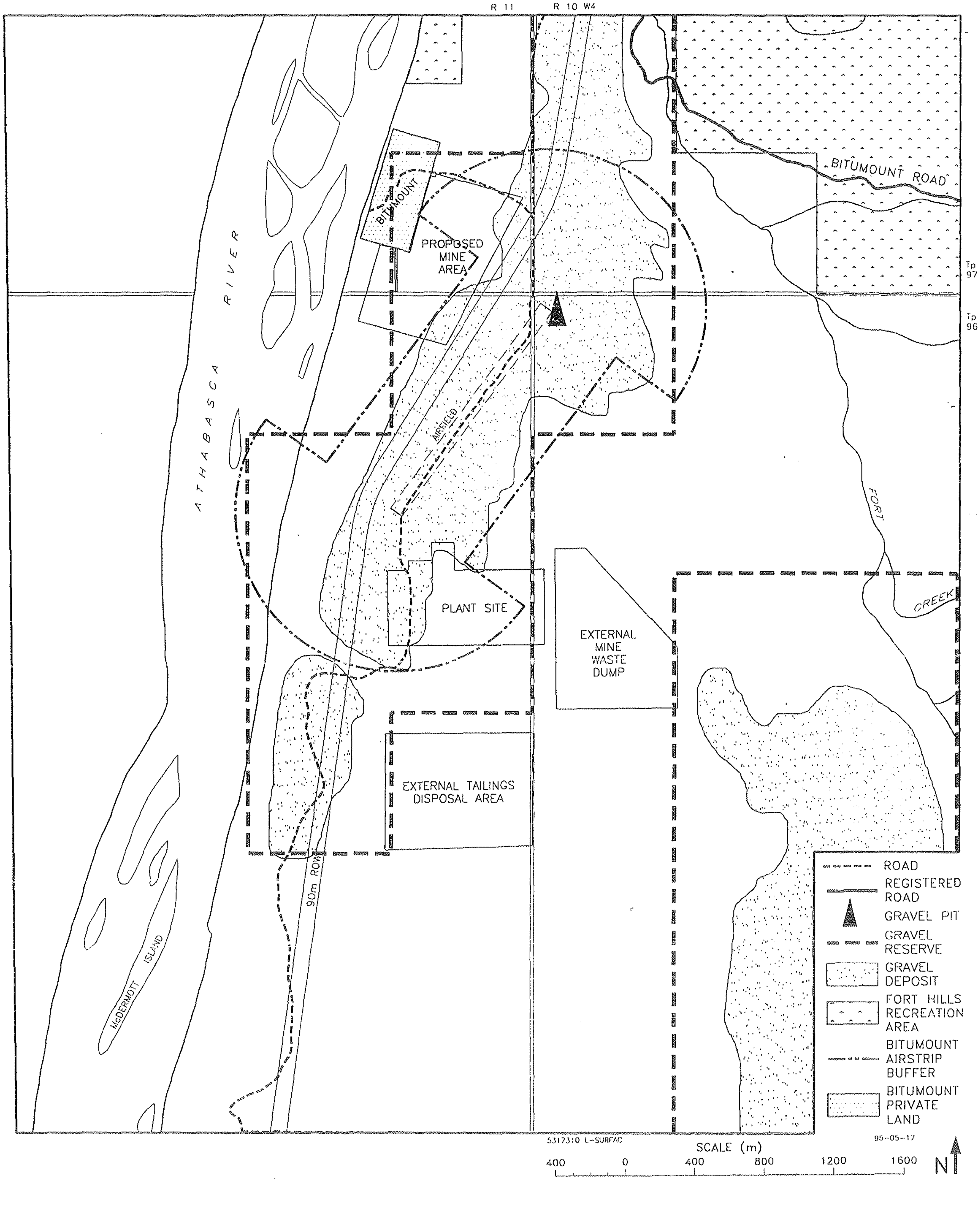


FIGURE 2.2 LEASE AND SURFACE RIGHTS

2.1.2 *Site Development*

The scope of the project is illustrated in the project schedule (Figure 1.2) which is divided into three major project phases:

- Site Preparation Phase from July 1, 1995 to October 1995 to prepare the site for subsequent winter construction activities. This work will involve upgrading Highway 63; initial site clearing for the purpose of placing a few trailers on site; preparation of the gravel base for the construction camp; and installation of a diesel generator for power. Other activities planned include monitoring and surveys for environmental baseline data and a drilling program to obtain geotechnical data and resource data for the proposed mine area.

- Phase I which will commence upon receiving project approval, with the start-up of the mine, with the planned start-up of the bitumen extraction and upgrading plants during the fourth quarter of 1996.

  - Construction camp facilities for up to 250 people will be installed. A part of the camp will be permanent and used for housing shift personnel during plant operation.

  - The lease site preparations will include physical upgrading of approximately 14 km of the future Highway 63 portion from its current end point to the lease site (Figure 2.1).

  - Preparations will also include tree and shrub clearing, muskeg drainage and removal on the areas of the plant site, external waste dump and tailings disposal area (Figure 2.1).

  - The construction of lease roads within and among these three areas and the mine area will take place.

  - Excavation and filling with granular material will occur in preparation for the building foundations.

- Phase II construction will commence during July 1996 with anticipated start-up of the mineral extraction plant during the third quarter of 1997.

The major criteria for locating the plant are:

- Minimizing the sterilization of bitumen and gravel resources.

- Minimizing the mine haul distance.

- Minimizing the disruption to the Highway 63 ROW.

- Ensuring that no rare plants were present.

- Minimizing impacts to wildlife, surface water and fisheries (plant is located away from Fort Creek).

2.1.3 *Mine Plan*

The preliminary plan for the mine to provide production from 1995 to 2002 is illustrated in Figures 2.3 and 2.4. The mine will cover an area of 50 ha. A detailed year by year description of mining activities is included in Section 4.4 of the AEUB Application.

Site preparation for the mine consists of four major activities that will be phased progressively over the life of the mine.

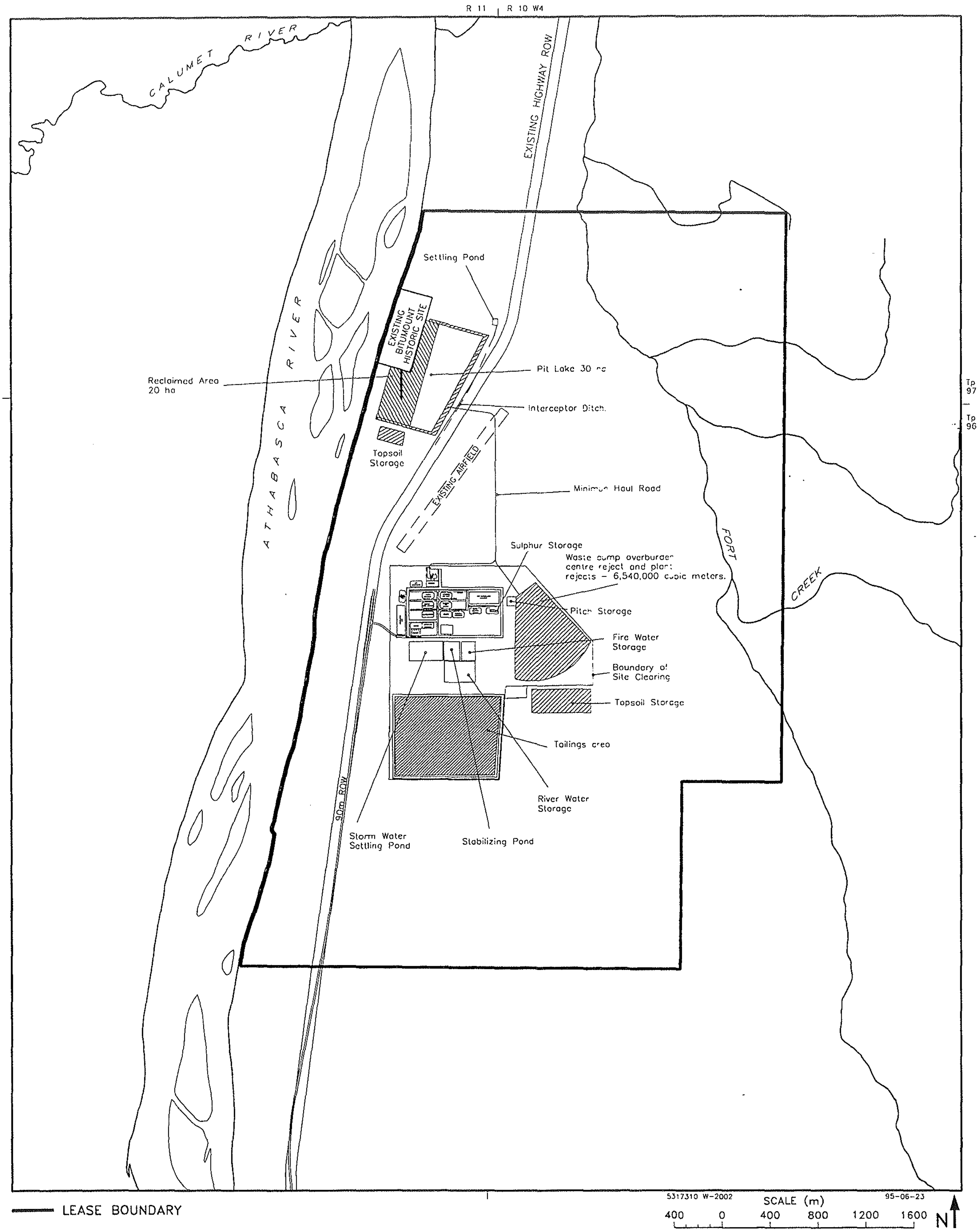
- Vegetation clearing,
- Muskeg dewatering,
- Depressurization of basal aquifer(s),
- Salvage of reclamation materials (muskeg and selected overburden),
- Overburden removal,
- Oil sand excavation,
- Backfilling of mine, and
- Replacement of salvaged soil for reclamation.

Mining activities will include the following:

- All tree clearing will be conducted in accordance with Alberta Forest Service regulations. Merchantable timber will be salvaged, and the rest of the vegetation debris will be incorporated into the base of the muskeg storage area.

- Drainage ditches will be constructed to dewater the muskeg several months prior to muskeg removal. Drainage water will be discharged to the settling pond adjacent to the mine, and discharged to the Athabasca River if it meets AEP requirements. Permanent interception channels will be constructed around the eastern and western borders of the mine pit to intercept surface drainage.

- Before mining can begin, certain sections of the basal zone (which is located below the ore grade oil sands) may need to be depressurized to ensure mine safety and productivity. The need for depressurization wells around the mine will be determined during a drilling program and pump tests slated for the summer of 1995 (Table 2.2). Current plans call for any saline water that will be encountered in the mine to be discharged to a settling pond near the plant to be used in the process or to be released into the Athabasca River. All effluent will be discharged to the Athabasca River only after meeting Alberta Environmental Protection Surface Water Quality Objectives (1977).



LEASE BOUNDARY

FIGURE 2.3 PRELIMINARY MINE DEVELOPMENT PLAN: END OF YEAR 2002

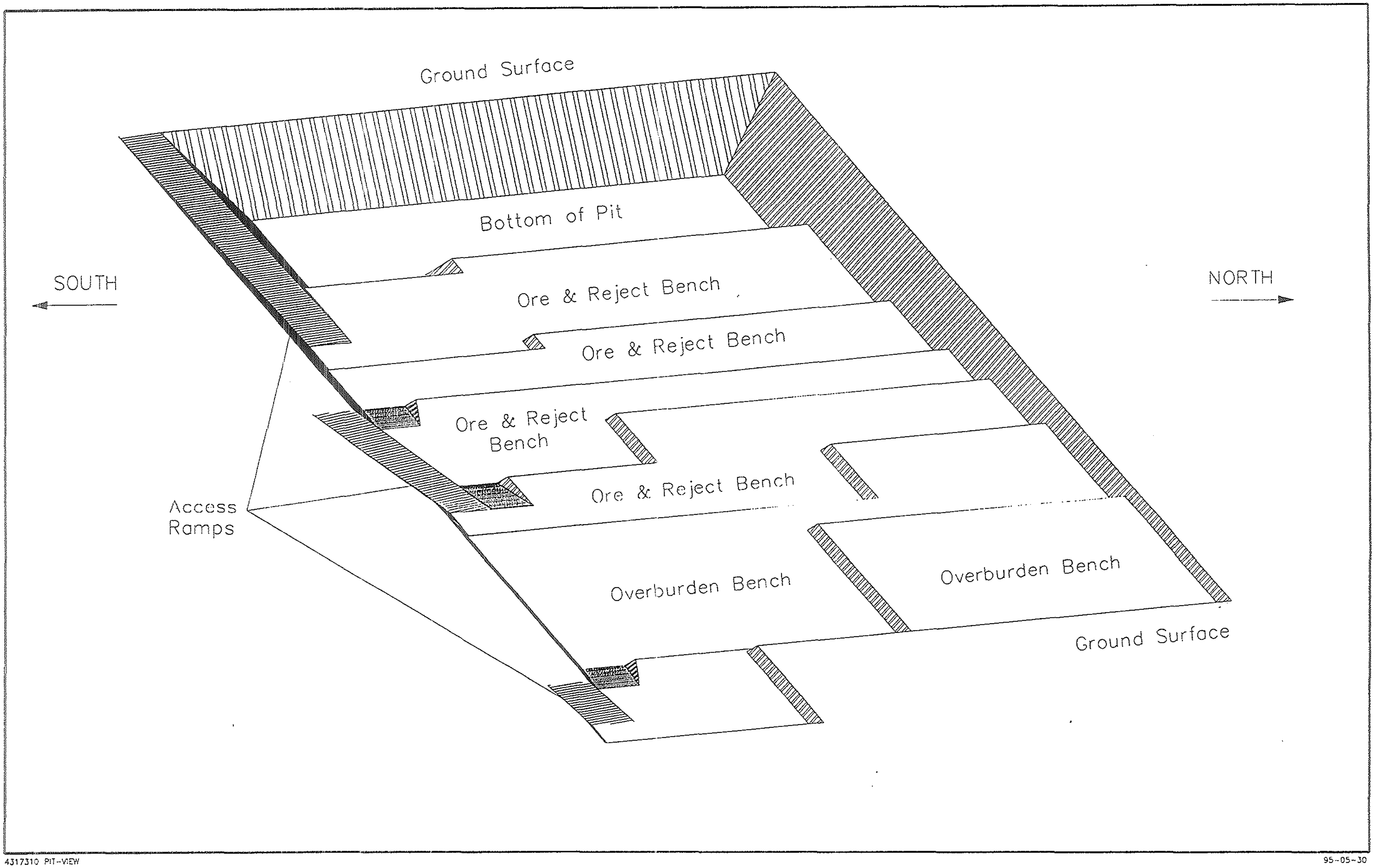


FIGURE 2.4 CONCEPTUAL MINE PIT VIEW

Table 2.2 Summary of 1995/96 Drilling Program.

Drilling Location	Purpose of Drilling
Proposed mine area, including area between it and the Athabasca River	• Delineation of waste/ore interfaces • Ore quality determinations • Identification of dips/fractures • Geotechnical/geological evaluations (sampling) • Hydrogeological evaluations (pump tests, piezometric elevations and water quality)
Plant site, tailings disposal area and mine waste dump	• Geotechnical and hydrogeological evaluations

Table 2.3 Mine materials handling and depositions.

Year	Annual Mining Volumes (1,000 m^3)			Cumulative Dispositions (1,000 m^3)			
	Overburden	Centre Reject	Oil Sands	Roads & Dykes	Mine Waste Dump	Tailings Disposal Area	Reclaimed Mine Pit
1996	420	0	105	420	0	115	0
1997	400	0	2,700	445	500	3,500	0
1998	1,800	2,250	3,370	445	3,000	7,000	500
1999	2,200	2,030	3,370	445	6,000	10,000	2,100
2000	2,360	2,030	3,370	445	6,500	14,000	6,000
2001	2,715	2,030	3,370	445	6,750	17,500	11,000
2002	2,350	2,030	3,370	445	7,000	21,000	16,000

- Quantities of overburden with physical and chemical properties suitable for reclamation will be selectively stripped along with associated muskeg and salvaged and stored at sites near the mine (Figure 2.3) for reclamation. Backfilling and reclamation of the mine will be initiated in 1998 (Table 2.3).

- Trucks and shovels will strip the overburden, which will be placed in the external mine waste dump near the plant until reclamation begins in 1998, or earlier depending on the results of detailed mine planning.

- Shovel excavators and haulage trucks will be used to excavate feed-grade oil sands from the mine and transport it to the plant. The mining operation will consist of 3 to 10 m high benches. Centre reject will be cast into the mined out area after the pit bottom has been exposed in Year 5 of mining.

- After the oil sand has been removed, mine areas will be progressively backfilled and reclaimed (Figure 2.5).

Alternate mining areas are available as shown in Figure 2.6; the alternate A shown is the preferred location; hereafter referred to as the "proposed" mine location. The factors used in locating the proposed mine included (also see Section 4.0, AEUB Application):

- Minimizing overburden depth and thereby reducing mining costs.

- The area of the proposed mine area has already undergone surface disturbances during the past.

- Location of a mine in the southeast area of the lease would require diversion of Fort Creek, at increased mining costs and with environmental impacts on the watershed.

- Location of a mine in the southeast area of the lease would affect gravel resources to a much larger extent than the proposed mine area. The proposed mine area involves no initial and minimal overall costs of gravel salvage during mining.

Drill hole data and cross-sections that were used in evaluating the reserves available on Lease 5 (see Section 4.3, AEUB application) are shown on Figure 2.7.

Table 2.4 lists the equipment requirements for the mining operation of the project.

Mine reclamation will begin with pit backfilling during 1998. The initial backfilled zone will be approximately 500 (horizontal) m from the pit wall and will require overburden material that can be compacted, will resist erosion and will support vegetation. The bulk of the in-pit fill will be random overburden and centre rejects. The surface layer (approximately 1 metre) will be capable of supporting vegetation.

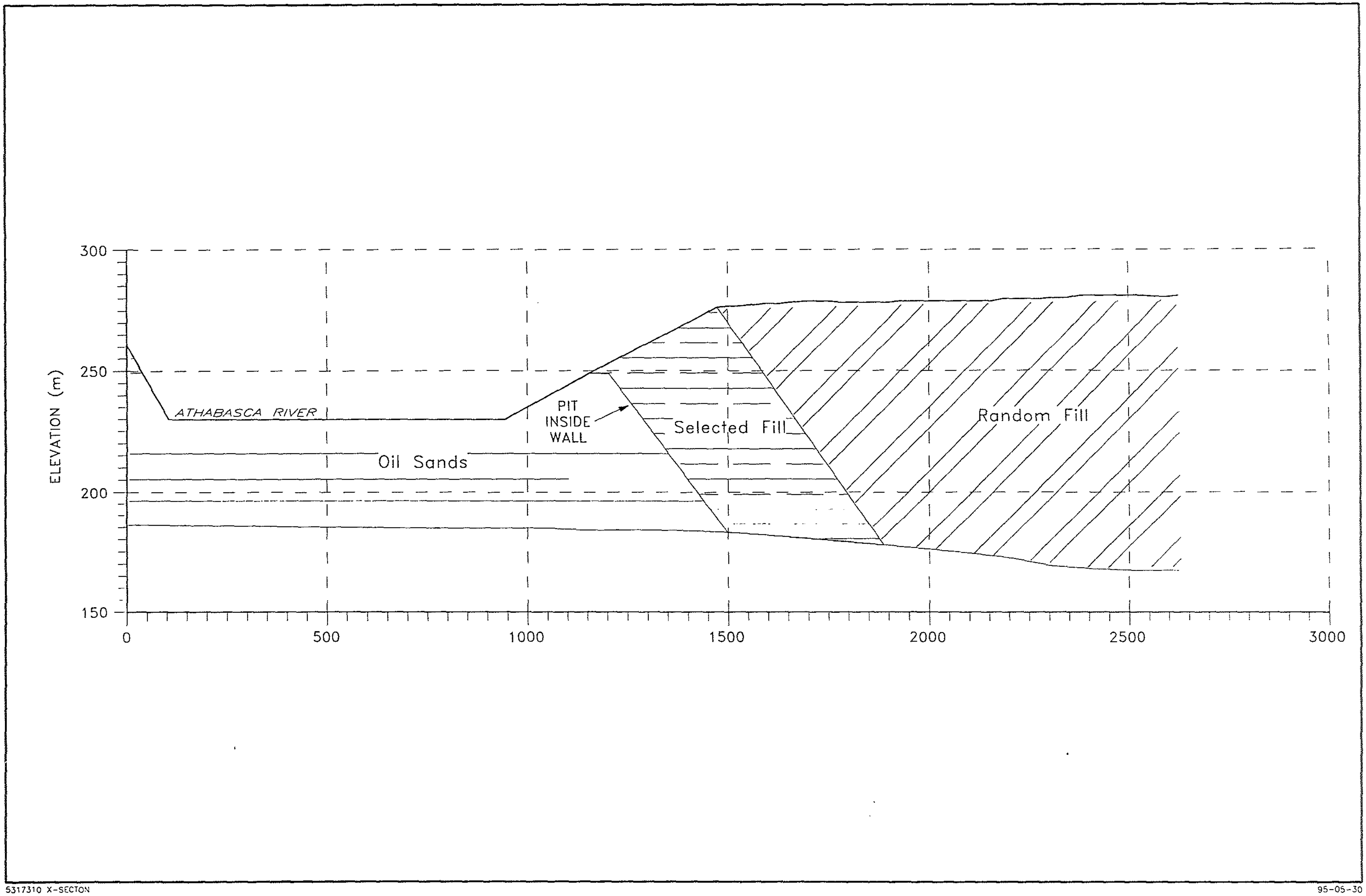


FIGURE 2.5 CONCEPTUAL CROSS-SECTION OF MINE RECLAMATION

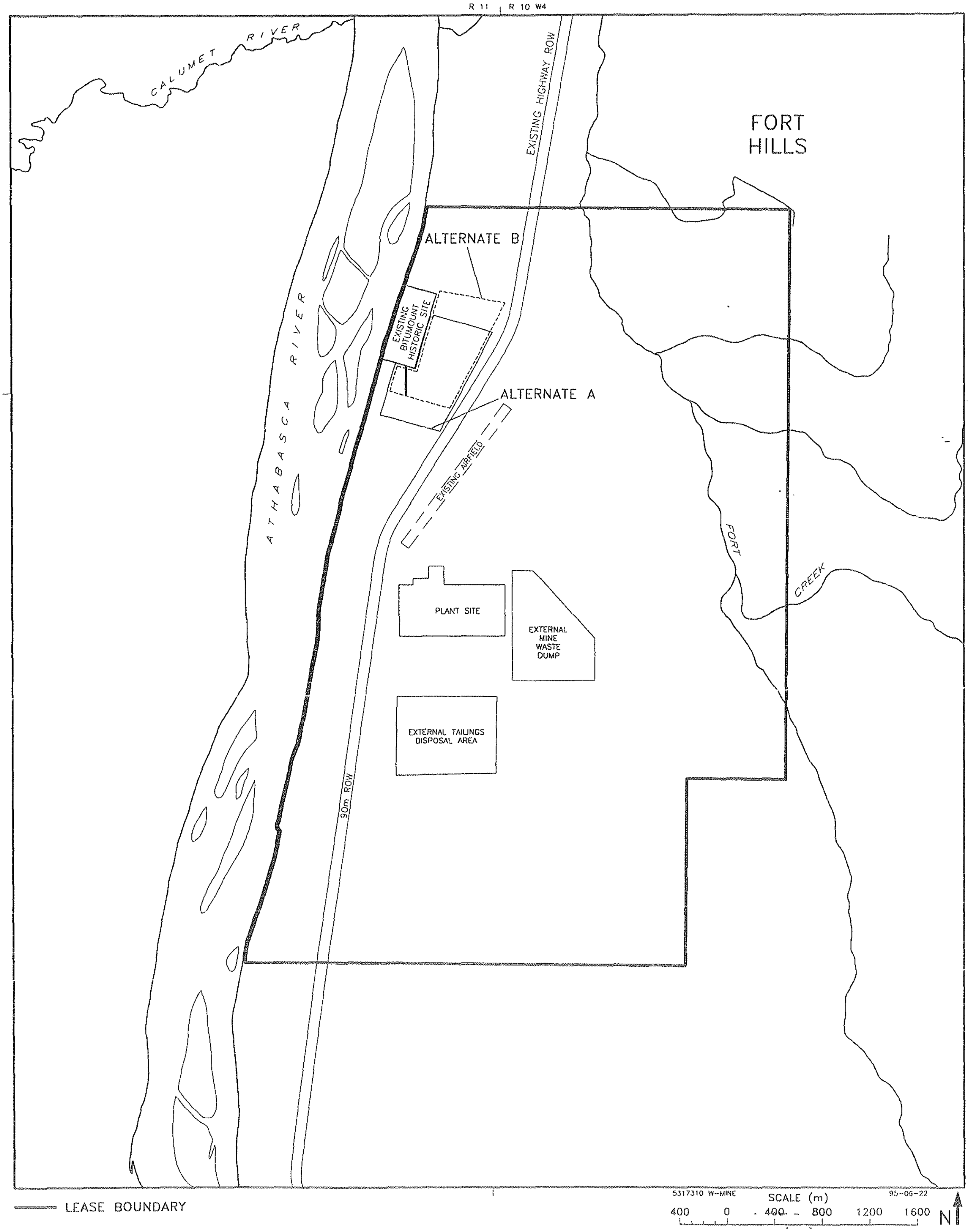


FIGURE 2.6 ALTERNATE MINE LOCATIONS

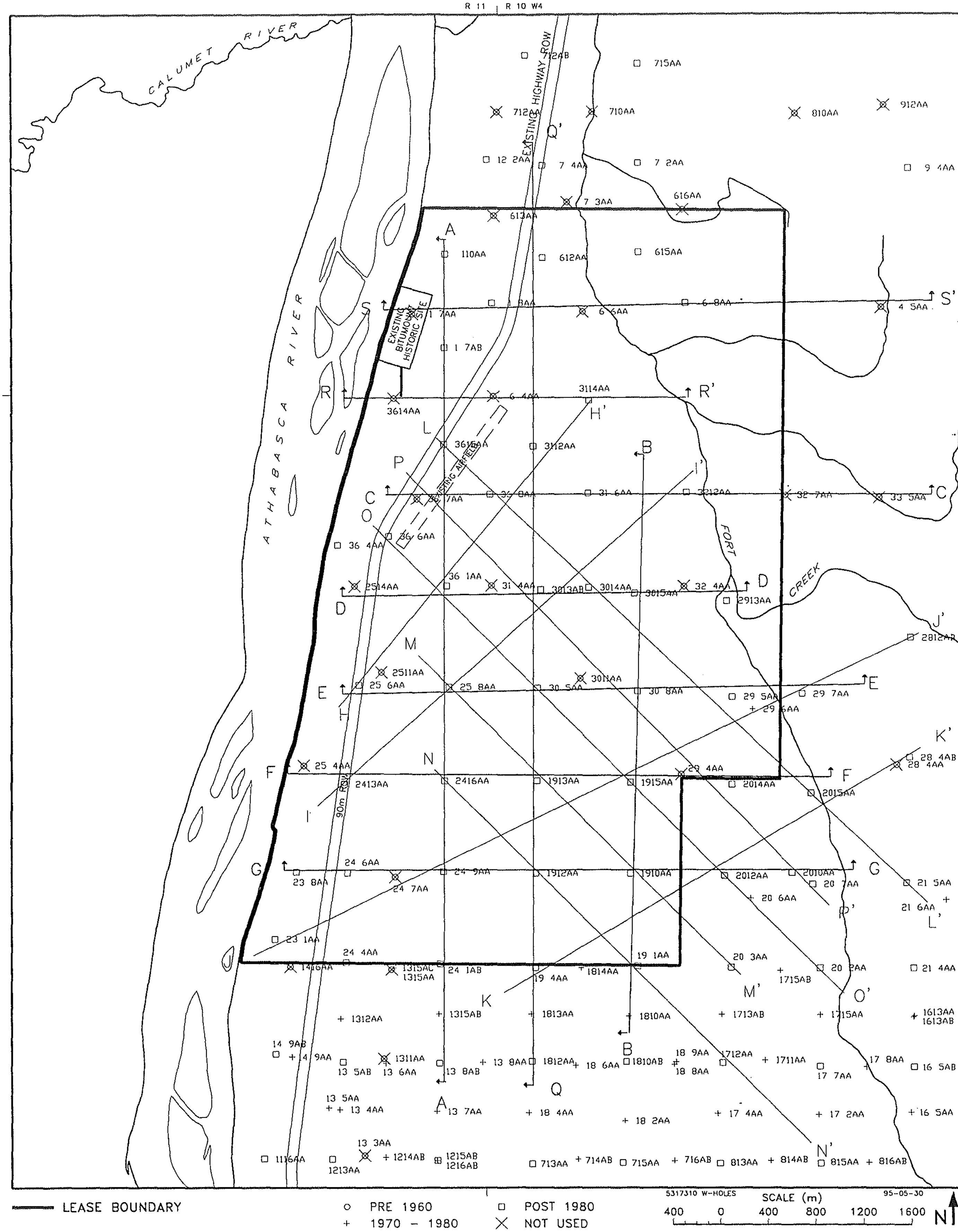


FIGURE 2.7 HISTORICAL DRILL HOLES AND CROSS-SECTIONS USED TO EVALUATE RESERVES

Table 2.4 Estimated equipment requirements.

Description of Equipment	Number Expected
85 tonne trucks	12
Hydraulic excavators	3
Shovel excavator	1
Support Equipment:[a]	
Bulldozers	2-3
Grader (for roads)	1

[a] Excluding equipment required in the tailings disposal area.

2.1.4 *Bitumen Extraction, Upgrading and Mineral Extraction*

The approach to the processing of oil sands is to integrate the extraction of bitumen from the sands and the onsite upgrading of the bitumen with a mineral extraction facility that will recover mineral values from the clay fraction of the tailings segregated during bitumen extraction. Many energy synergisms as well as economic benefits are realized with this approach compared to conventional oil sands technology.

The project is experimental in nature. The technology for bitumen extraction and upgrading and for minerals will be tested at a scale of 1674 m^3/sd of PCO (or 21 493 t/sd oil sands) to prove out the technology developed by Solv-Ex at their pilot plant in Albuquerque, New Mexico. The project will be developed in two phases as follows:

- **Phase I:** mining, bitumen extraction and upgrading to produce PCO.

- **Phase II:** mining, bitumen extraction and upgrading to produce PCO as well as extraction and separation of mineral values from clay fines to produce alumina, potassium sulphate, ferrous sulphate and byproduct sulphates.

2.1.4.1 Overview of the Bitumen Extraction Processes

The bitumen extraction process is a hot water based process which operates isothermally at atmospheric pressure. The bitumen is detached from the sand in log washers through contact with low pressure, live steam and hot water forming a bitumen froth and slurry. The froth floats to the top of a separation vessel while the slurry is removed as middlings (a suspension of clay mineral fines) and as bottoms (coarse sand). The bitumen froth is treated at a relatively high temperature to remove most of the entrained solids and water and sent to upgrading. The coarse sand bottoms are washed clean with water. The wash water is drained from the sand and recycled for upstream hot water bitumen extraction. The damp sand is reslurried and disposed to the tailings area. The middlings are further processed to separate them into clay and silt fractions. The silt fraction stream is disposed with the sand tailings. The thickened clay fraction is mechanically dewatered to 70 wt.% solids.

Heat losses will be minimized in the various steps of bitumen extraction, by internal recycling of hot water to the extent that only a 15°C water temperature drop will occur across the bitumen extraction plant. Cold make-up water will preferentially be used in a last step of sand tailing washing to recover heat from the sands.

All of the dewatered clay will be trucked to the tailings disposal area during Phase I while only part of it will be trucked to disposal during Phase II. The balance will be thermally dried to 95 wt.% solids and thereafter be used as feedstock to the mineral extraction plant.

Further details of the Solv-Ex bitumen extraction process and equipment are outlined in Section 5.1 of the AEUB Application.

2.1.4.2 Overview of the Bitumen Upgrading Processes

Solv-Ex has reviewed various emerging technologies available for processing bitumen and concluded that the Shell Soaker Visbreaking (SSV) process provides the most advantageous and cost effective upgrading alternative for a bitumen and alumina processing complex. It is a thermal cracking process with the following advantages:

- It is modified continuous thermal cracking technology, providing higher conversion and more stable residue than conventional visbreaking.
- It directly accepts a wide range of feedstocks with high sulphur and heavy metal contents such as bitumen extracted from oil sands.
- It does not require any hydrogen, catalyst or pressure equipment.
- The cracked distillates are mostly light and heavy gas oils with less unsaturates than coker distillates.
- Coking in the bitumen heater coils is minimized by short residence time which is effected by employing high liquid velocities and steam injection. Thermal cracking takes place in a soaker drum where the conditions are such that a greater yield of useful distillates is produced at a reduced fired heater requirement. Special internals are employed to minimize backmixing.
- It is the most flexible of the evaluated technologies because it can be modified relatively easily to produce a mildly cracked bitumen, a severely cracked bitumen or PCO with minor changes to the plant operation.

The bitumen feed is preheated and fed to the SSV process units where pitch is removed for stockpiling and pipelineable crude oil (PCO) is produced. PCO is a blend of the naphtha, light gas oil (LGO) and heavy gas oil (HGO) fractions produced. Sour fuel gas is produced during upgrading and is sent to an amine contactor and sulphur recovery plant for removal of hydrogen sulphide. The sweet fuel gas is send to the SSV process unit and utility plant. Sulphur will be stockpiled on the plant site during Phase I. During Phase II, the stockpiled and produced sulphur will be used to manufacture sulphuric acid which will be used in the mineral extraction plant.

Further details of the upgrading process are outlined in Section 5.12 of the AEUB Application.

2.1.4.3 Overview of the Mineral Extraction Processes

The mineral extraction plant is designed to produce 206 t/sd of alumina (Al_2O_3) from 1200 t/sd of dry clay-fines. It is also designed to produce the additional products of metal sulphates (K_2SO_4,

$FeSO_4 \cdot 7\ H_2O$ and byproduct sulphate which is a mixture of various metal sulphates of aluminum, iron, potassium, calcium, magnesium and trace metals). Clay minerals are mainly composed of:

- kaolinite, an aluminum-hydroxide-silica-oxide;
- illite, a potassium-silica-aluminum-hydroxide;
- montmorillonite, an aluminum-hydroxide-silica oxide;
- calcium and magnesium carbonates; and
- iron oxides/hydroxides.

By agglomerating the clay fines with concentrated sulphuric acid, followed by curing and a hot acid leach, most of the Al, K and Fe and all the Ca and Mg will be extracted as dissolved metal sulphates. A salt liquor and slurry is formed. The process is described in detail in Section 5.2.1 of the AEUB Application.

2.1.5 *Ancillary Facilities (Utilities, Transportation, Co-Generation)*

The Solv-Ex Project will require a full complement of utilities to support both the mine and the process plants. The utilities systems are summarized in Section 1.2.

The principal sources of energy for the project will be:

- Fuel gas (generated in the upgrading process), and
- A natural gas or diesel fuel (No. 2 fuel oil).

Currently, there is no pipeline supply of natural gas to Lease 5. However, Solv-Ex is currently negotiating with Syncrude, Simmons and Chevron regarding the extension of a pipeline from the Syncrude Lease (on the east side of the Athabasca River where a 250 mm pipeline current exists) to Lease 5. This pipeline will be routed along the 90 m wide ROW which includes Highway 63 (Figure 2.8).

The upgrading sector will be a generator of fuel energy, i.e., fuel gas, most of which will be consumed in the upgrading sector to heat the mixture of bitumen and residue and generate ebullating steam for injection into the mixture. The upgrading and mineral extractor sectors will generate steam energy, primarily from the burning of hydrogen sulphide in the sulphur recovery plant and the burning of elemental sulphur in the sulphuric acid manufacturing plant.

The net process steam requirement of the plant will be provided from fuel fired boilers and heat recovery steam generators located in the exhaust ducts of gas turbines provided to generate electricity by means of turbine driven generators. The turbine exhaust stacks will be equipped with stack burners to increase the steam generating capacity of the heat recovery steam generators. The fuel for the boilers, gas turbines and duct burners will be natural gas or diesel.

Electrical power will be generated onsite so no electrical transmission line will be required. Emergency power will be provided to selected drives and controls by stand-by diesel generators.

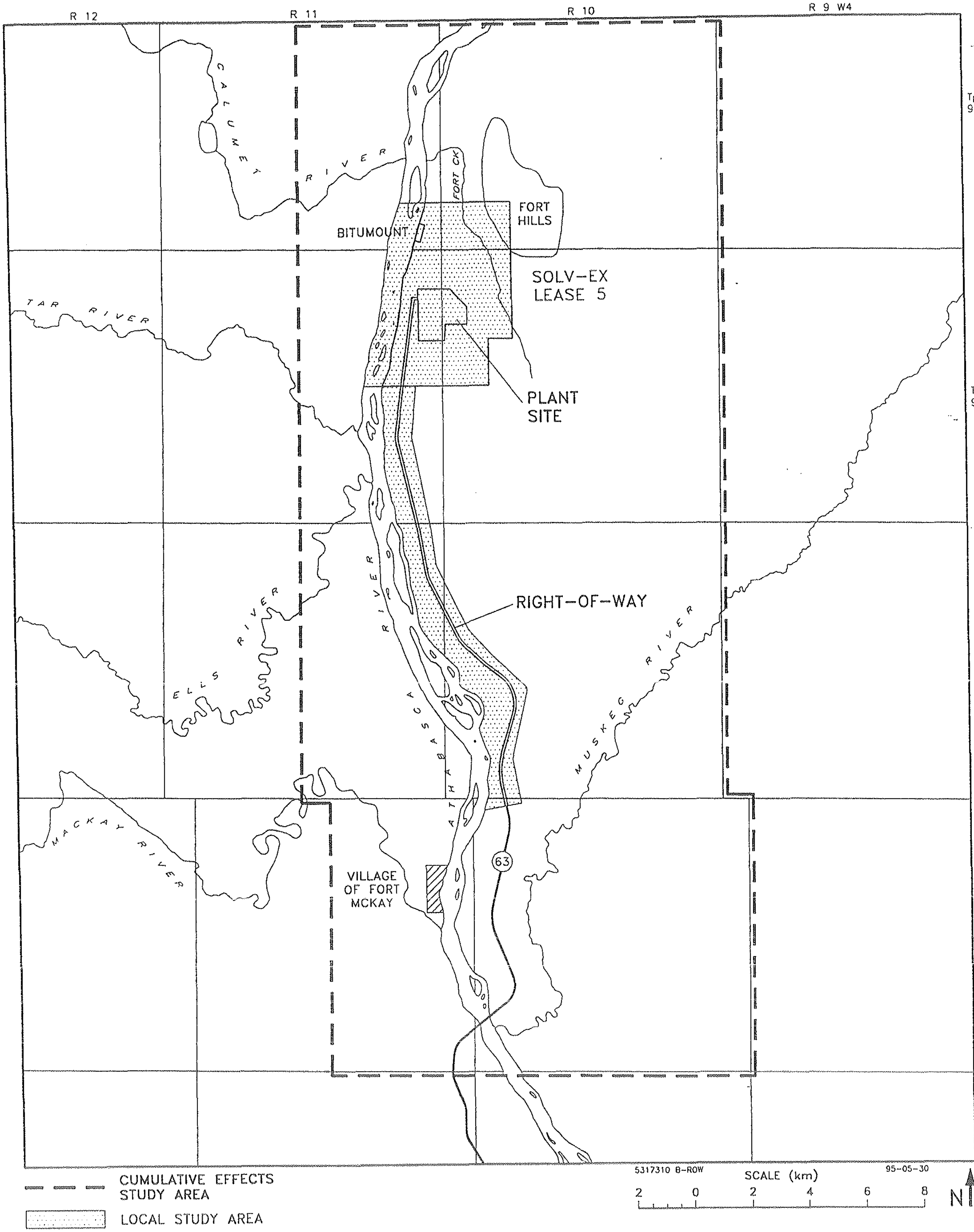


FIGURE 2.8 RIGHT-OF-WAY FOR HIGHWAY 63 UPGRADE, NATURAL GAS PIPELINE

The energy balance for the project is shown on Figure 2.9.

2.1.5.1 Transportation

Currently the only land-based access to the site is by means of the winter road to Fort Chipewyan. There is a cleared road right-of-way that will be used to upgrade the road systems as follows:

- The lease site preparations will include physical upgrading of 14 km of the future Highway 63 portion from its current end point to the plant site (Figure 2.8).

- The construction of lease roads within and among these three areas and the mine area will take place.

The upgrading of 14 km of Highway 63 is consistent with the policies of provincial and municipal governments who want to improve access to northeast Alberta. The winter road to Fort Chipewyan will not be affected, so safe access will be maintained. No traffic bypass of the area will be required. Increased public access on the east side of the Athabasca River will have implications on:

- Increased road maintenance.
- More tourists visiting the historic site.

There will be increased traffic levels on Highway 63 to meet the needs of the plant as shown on Table 2.5. The truck traffic will be a maximum of 56 trucks/day when the plant is in full production.

2.1.6 *Granular Resources*

Granular materials are required for a wide variety of purposes on the Solv-Ex site, but predominantly for road construction and site preparation. During the period 1995 to 2002, approximately 240 000 m^3 of gravel will be required.

Currently granular materials are planned to be extracted from the Alberta Transportation gravel pit south of Lease 5 (Figure 1.3). The plant site and mine will be built over a minimal portion of a gravel reservation (Figure 2.2).

2.2 Management Systems for Environmental Protection

Environmental control systems will be implemented to minimize and monitor the impacts of the Solv-Ex project on the environment. These are discussed below under water management, byproduct, waste and chemical management, waste management, atmospheric sources and emissions, and environmental monitoring.

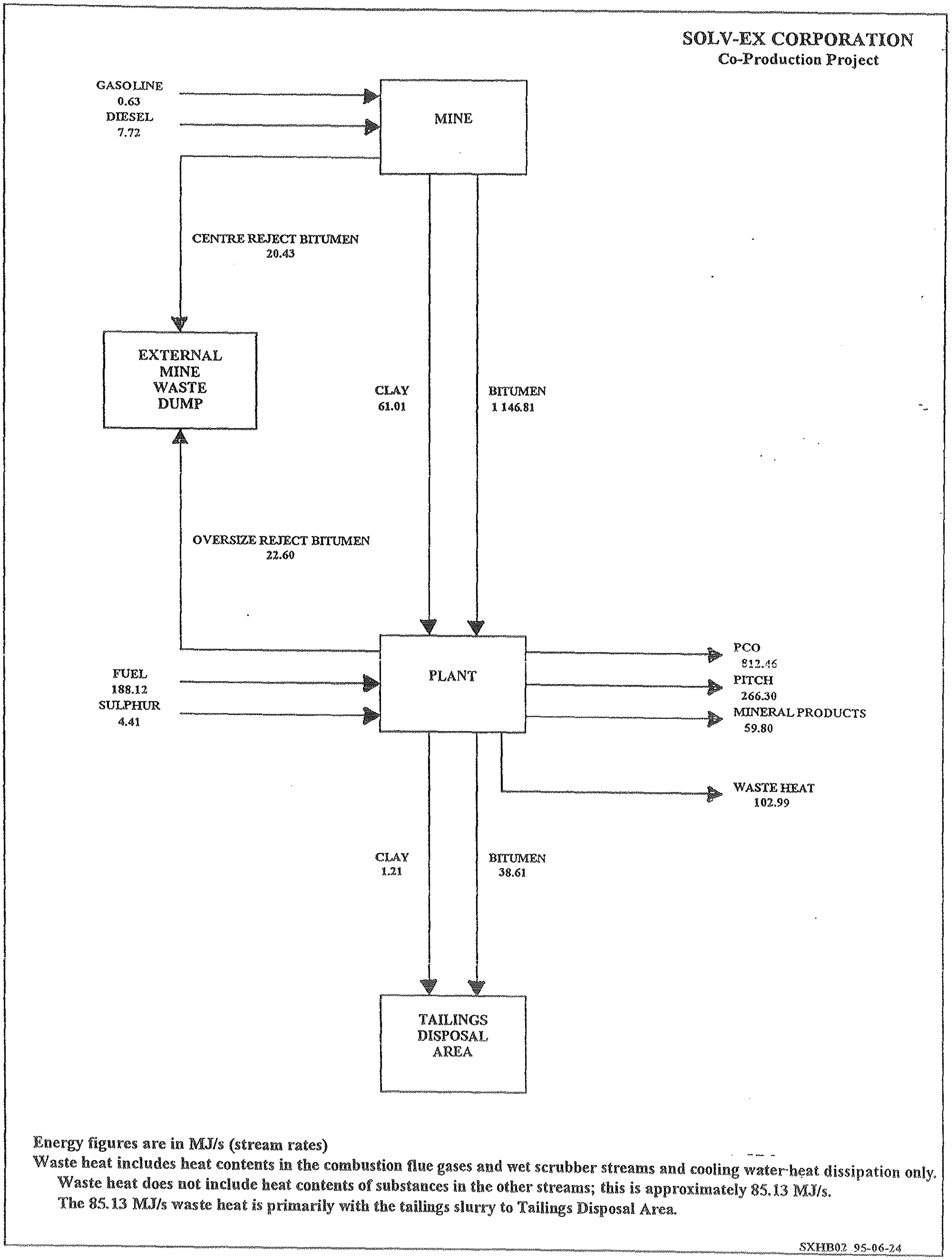


FIGURE 2.9 ENERGY BALANCE

Table 2.5 Changes in Traffic flow on Highway 63 between Fort McMurray and the Solv-Ex lease area during construction and operation phases. Numbers in parentheses are percentages of average 1992/1993 traffic levels.

Portion of Highway	Average 1992/1993 Traffic Levels (Average Annual Daily Traffic)[(a)]	Future Projection (Al-Pac, Susan Gravel Pit, and Solv-Ex)[(b)]	Solv-Ex Projected Traffic Increase	
			Construction[(c)]	Operations[(d)]
Fort McMurray to Suncor Turnoff	3485	290 (8.3)	200 (6)	234 (7)
North of Syncrude Turnoff	2810	290 (10.3)	200 (7)	234 (8)
South of Fort McKay Turnoff	185	290 (156.8)	200 (108)	234 (127)
North of Fort McKay Turnoff	80	290 (362.5)	200 (250)	234 (293)

(a) Source: Alberta Transportation and Utilities. 1995. Technical Services Planning Branch, Edmonton.

(b) Based on an estimated 40 truckloads of wood per day during peak harvest periods during the winter months, 20 truck loads of gravel from the Susan Gravel Pit and Operation figures for Solv-Ex shown above.

(c) Based on 200 cars one way per day.

(d) Based on 110 PCO trucks one way per day, 20 mineral trucks one way per day, 4 employee buses one way per day and 100 private vehicles one way per day.

2.2.1 *Water Management*

The water management system comprises the following components: water supply system, the wastewater control system, and the surface and groundwater quality monitoring programs (monitoring systems are discussed in Section 2.2.4).

2.2.1.1 Water Supply

The annual water needs for the Solv-Ex facilities are estimated to be between 3.6 to 5.0 Mm^3/a. Water will be required at an estimated rate of 10 405 m^3/sd to replenish the following consumptions:

- 4318 m^3/sd (42%) of water lost in bitumen extraction,
- 198 m^3/sd (2%) of water lost in bitumen upgrading,
- 2310 m^3/sd (22%) lost in mineral extraction, and
- 3579 m^3/sd (34%) for utilities and offsites.

The water balance for the facilities is illustrated in Figure 2.10. Water sources for the plant will include: water drawn from the Athabasca River, groundwater collected through pumping systems and possibly stormwater runoff. The water will be pumped from the Athabasca River where a shore-based channel will be excavated to build an ice free intake pipe. Process waste water recycling will be maximized within and among the process sections to the extent possible to minimize water requirements without jeopardizing process chemistry and equipment durability. The percent breakdown of water sources are: 39% river water, 8% recycle waste water, and 53% tailings return water for normal plant operations.

The water balance (Figure 2.10) has calculated the plants water needs without relying on mine drainage and seasonal runoff since these values are unknown at this time. During plant start-up, the daily water requirement will be up to 22 289 m^3/sd which is over 250% of the daily requirement of 8656 m^3/sd under normal operations.

The water system is designed such that runoff from heavy precipitation events will be able to collect in the storm water retention pond.

The water balance (Figure 2.10) outlines the necessary daily discharge of 2028 m^3/sd. This water will only be released after it meets AEP guidelines, and will originate from the waste water stabilization pond.

Currently, there is no data to suggest that there will be water interchange between the Athabasca River and the mine. Since it is an important mine safety issue, the question will be explored during the detailed mine planning phase, which is scheduled for the summer of 1995.

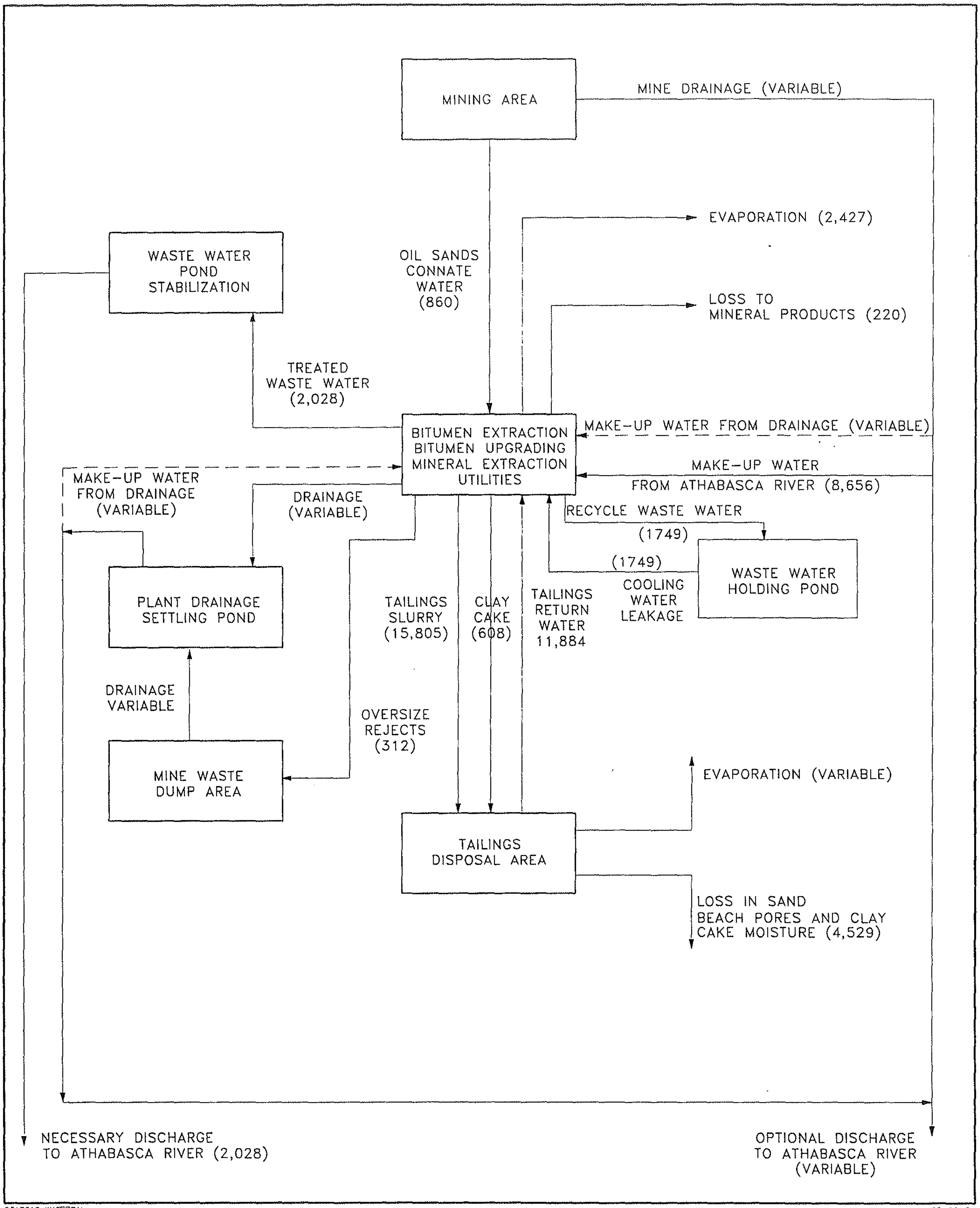


FIGURE 2.10 WATER BALANCE (m^3 PER STREAM DAY)

2.2.1.2 Wastewater System

The wastewater control systems involve the following features:

- Surface water from all disturbed areas of the mine and plant site will be collected through ditches and diverted to two settling ponds. Water that meets Alberta Environmental Protection (AEP) guidelines, surface water objectives will be released to the Athabasca River. There will be two settling ponds:

    - The settling pond near the mine that will collect muskeg drainage and mine interception ditch water. This water will be disposed to the Tailings Disposal Area or Athabasca River.

    - The settling pond south of the plant site that will collect non-contaminated surface drainage from the plant perimeter.

- Saline Basal Aquifer water may be encountered near the bottom of the mine pit. A system of wells may be necessary in the vicinity of the pit to depressurize the aquifer and prevent floor heave and groundwater into the mine. The water, due to its high salinity, will likely be diluted with river water to meet AEP discharge requirements and be pipelined to the Athabasca River for disposal. If the salinity and chloride content are low and if the rates of depressurization water are not larger than the bitumen extraction water make-up requirement, its process use will be considered and tested with respect to chloride build-up levels.

- The plant is designed so that all water that has been process-affected will be contained on-site and will not be discharged to the environment. Waste water from the upgrading process units, from tank cleaning and tank farm drainage, and water exposed to oil throughout the process area is collected via the oily water sewer system. This will include all surface runoff from on-site areas which can potentially be contaminated with hydrocarbons, as well as floor washings from process buildings and conveyor tunnels. Also dumped to the sewer will be non-toxic aqueous wastes from water treatment and steam generation equipment, after neutralization. The Oily Water Sewer System will be fed to an oil skimming facility followed by a waste water settling pond for removal of hydrocarbon contamination and particulates. The separated hydrocarbon phase will be pumped to the Slop Tank for recycling into the upgrading process.

- Sanitary effluent will be treated at the Biological Waste Water Treatment Plant, stored in the stabilization holding pond and disposed to the Athabasca River after it meets AEP requirements.

The settling ponds will be designed using the following criteria:

- Runoff volume from a 1 in 10 year storm of 24 hour duration,
- Precipitation volume on the pond,

- Pond depth allowance (e.g. 0.5 m) for sediment accumulation, and
- Freeboard depth allowance for wave action/erosion of dykes and pond side slopes.

Potable water systems are subject to short periods of high consumption within long periods of low consumption. The treatment system will be designed for a constant water feed rate of 130 m^3/d with a potable water storage tank absorbing the consumption surges. The storage tank will be designed for one day of consumption.

2.2.1.3 Wastewater Treatment

During the site preparation from July 1 to October 1, 1995, all on-site domestic sewage will be collected in a holding tank from where it will be pumped into a truck and transferred to a licensed sewage treatment system in the general area. Approximately 20 to 30 people will be on-site during this period. After this period, domestic sewage will be chemically and biologically treated in facilities similar to these on off-shore production platforms. Effluent will be disposed into the Athabasca River only after meeting Alberta Environmental Protection guidelines.

Wastewater treatment is based on the principle of total recycle and a one plant sewer system.

Wastewater to be treated include collected oily water, storm water run-offs and drains. Sanitary waste water will also be treated separately.

2.2.2 *Byproduct, Waste and Chemical Management*

Table 2.6 summarizes the materials produced during Phase I and II of the project, while material balances for the bitumen extraction and mineral extraction are shown in Figure 2.11. This section addresses the handling of byproducts such as tailings, sulphur and pitch, the handling of solid wastes and the handling of priority substances.

2.2.2.1 Tailings Management

Tailings management will consist of the following:

- In Phase I tailings from the bitumen extraction process will consist of clay fines, gravel, silt and sand. There will be no heavy metals in the tailings as it will be contained in the pitch. The tailings disposal area will be clay lined.

- In Phase II, a part of the clay fines will be dried and used as feedstock for the mineral extraction. The sand rejected will be thoroughly washed, then dewatered. The moist sand will be transported to the tailings disposal area. For the first several years of plant operation, the tailings will be placed in surface piles. In-pit disposal of these tailings may occur during the six year period; however, definitive mine planning is required to confirm this.

Table 2.6 Materials, storage and disposal.

Materials	Storage Method	Storage Location	Disposal Method	Disposal Location
Bitumen	Hoppers	Plant	Processed into PCO	Plant
PCO	800 m^3 Floating Roof Tanks	Plant	Marketed	Various
Al_2O_3	1600 m^3 Silos	Plant	Marketed	Various
$FeSO_4 \bullet 7 H_2O$	1000 m^3 Silos	Plant	Marketed	Various
K_2SO_4	1000 m^3 Silos	Plant	Marketed	Various
Byproduct sulphates	4000 m^3 Silos	Plant	Marketed	Various
Sulphur	Phase I - Blocks Phase II - 4800 m^3 liquid tank	Plant	Used in Process	N/A
Pitch	Blocks	East of Plant	Reused or Burial	To be Determined
Tailings	Conical Piles	South of Plant	Burial	South of Plant

N/A - Not Applicable.

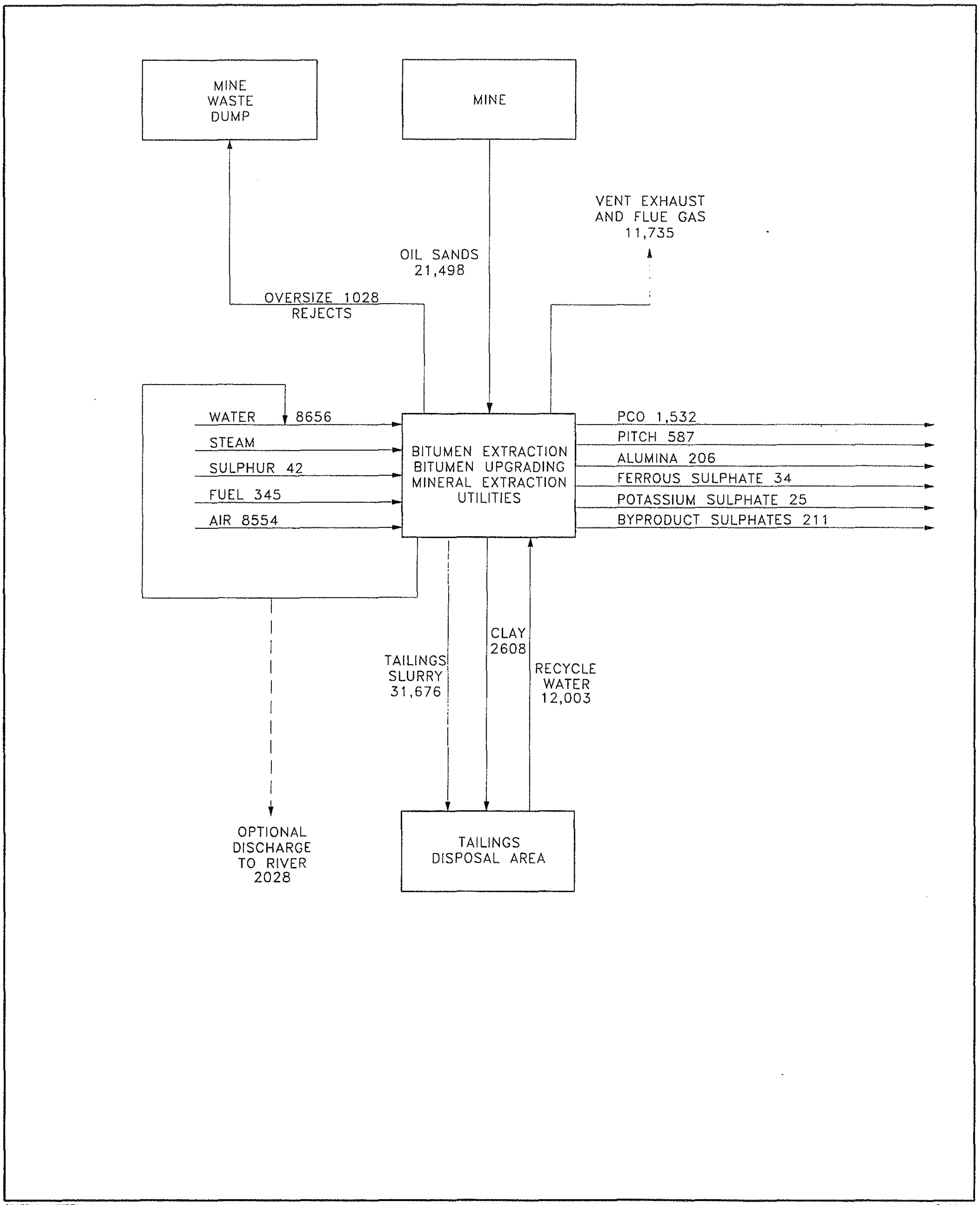


FIGURE 2.11 MATERIAL BALANCE (TONNES PER STREAM DAY)

The tailings will contain minimum bitumen and minimal free water. Seepage of entrained water will be controlled with perimeter ditches. No hydrocarbon fumes, odors or seepage are expected from the tailings piles. Due to the moisture content of the tailings, blowing dust is not anticipated.

2.2.2.2 Sulphur

During Phase I, sulphur will be stored at the site in block form for future use. The sulphur will be used (starting at year 2) when Phase II of the project (mineral extraction) will be implemented (Figure 2.12). At the beginning of Phase II total sulphur storage will amount to approximately 5000 tonnes in solid form. It will be contained in clay-lined or concrete asphalt ground packs. The permeability of the chosen liner will be in accordance with the soon to be issued AEUB Storage Requirements for the Upstream Petroleum Industry.

The ditches and settling pond for the sulphur storage pad will also be lined with limestone cobbles to reduce acidity caused by soil bacterial activity. In addition, the setting pond for the sulphur storage pad will be equipped with a lime treatment and neutralization unit designed to adjust the pumped discharge to neutral pH before release to the plant perimeter ditch system.

During Phase II sulphur will be imported to the sulphuric acid manufacturing plant at a rate of 41.2 t/sd because the sulphur recovery plant cannot fully satisfy the demand. Molten sulphur will be trucked to site from suppliers. Provision will be made for neutralizing acid spills within the containment area and dilute acid from floor washdown at the Acid Plant and at the Mineral Extraction Plant. Liquid sulphur will be stored in liquid form in a 4800 tonne capacity tank.

2.2.2.3 PCO and Pitch

Produced bitumen will be stored in heated, insulated and single seal internal floating roof tanks. The PCO will be blended in on-line mixers and stored in heated, insulated and single seal internal floating roof tanks of 800 m^3 capacity each. The tankage area (which will include tankage for PCO, bitumen, gasoline and diesel fuel) will be surrounded by a dyke to contain potential spills. The ground surface and dyke surfaces will be lined with clay or a gravel bentonite mixture to prevent seepage of spilled liquids to the groundwater. The volume within the dyked area, the permeability of the liner and its construction will be in accordance with soon to be issued AEUB requirements (Storage Requirements for the Upstream Petroleum Industry).

Pitch will be stockpiled on site for future use. The pitch may eventually be consumed as fuel if pitch burning boilers are installed. The pitch will contain heavy metals such as vanadium and nickel from the bitumen, but since the pitch has a glasslike consistency, the heavy metals will not likely leach into the groundwater. A clay or synthetic liner or asphalt/cement pads will be used as a base for the pitch stockpile. The option of recombining the pitch with the PCO for the production of heavier hydrocarbon is under evaluation. If implemented, this option will eliminate or reduce the need for pitch stockpiling.

The pitch storage area will be located immediately east of the plant site. The pitch storage areas will be lined with compacted clay if sufficient clay is located. Otherwise they will be paved with concrete or asphalt. Each of the storage areas (pitch, sulphur) will be provided with subdrain

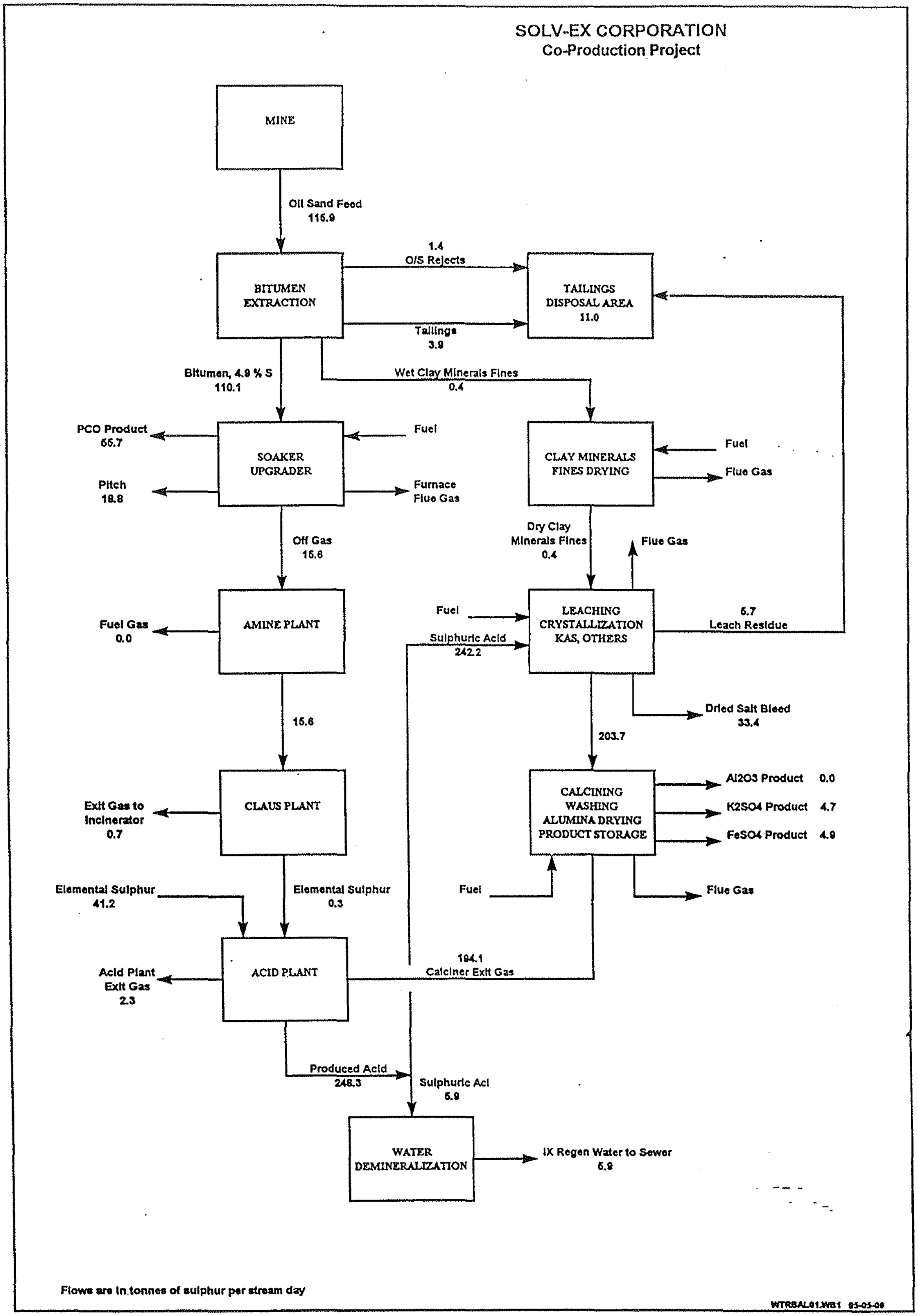


FIGURE 2.12 SULPHUR BALANCE FOR 14,000 BPSD BITUMEN PRODUCTION

piping routed to manholes with pumped discharge to a surface drainage retention pond. These measures will be provided as a means of ensuring continuous integrity of the liners by periodic inspection for a significant amount of subdrainage, and sampling and analysis of the subdrainage. Surface drainage from each area will be collected in lined ditches and routed to the lined surface drainage retention pond for accumulation, settling and sampling. The samples will be analyzed for pH, oil and grease, sulphides and selected metals. The drainage will be released to the plant perimeter ditch system if its quality meets AEP requirements. Otherwise it will be directed to the process water recycle system.

In Phase II the solid products Al_2O_3, $FeSO_4$, K_2SO_4 and byproduct sulphates will be stored in silos. The silos have conical bottoms and will discharge directly into the top of the transport trucks.

2.2.2.4 Waste Management

The management of wastes for the Solv-Ex facility includes:

- Solv-Ex promotes the four R's for handling solid waste: reduction, reuse, recycling and recovery.

- Garbage will be compacted and transported by truck to an AEP approved landfill during Phase I of the project. Over the longer term, Solv-Ex may make a separate application under AEPEA for an on-site industrial landfill. A black bear management program will be in effect throughout the entire project at all garbage disposal sites. Fencing and monitoring will make the garbage disposal site inaccessible to black bears. The handling of animals that become a nuisance or a safety hazard will be resolved with the Alberta Fish and Wildlife Division.

- Special wastes will be transported off-site according to WHMIS (Waste and Hazardous Material Information System) and TDG (Transportation of Dangerous Goods) classifications and requirements.

2.2.2.5 Priority Substances

The Priority Substances List (PSL) of the Canadian Environmental Protection Act (CEPA) is a list of substances that the Federal Ministers has decided should be given priority in assessing whether they are toxic or capable of becoming toxic". The CEPA defines a substance as toxic if it is entering or may enter the environment in a quantity or concentration or under conditions:

- Having or that may have an immediate or long-term harmful effect on the environment,
- Constituting or that may constitute a danger to the environment on which human life depends, or
- Constituting or that may constitute a danger in Canada to human life or health (CEPA Part II, Section 11 as published in ECO-LOG).

The types and quantifies of chemicals that will be used at the Solv-Ex facilities are listed in Table 2.7. The following substances are listed on the Priority Substances List:

- 1,1,1-Tricloroethane
- Benzene
- Toluene
- Trichloroethylene
- Cd
- Cr
- Ni

A Ministers' Expert Advisory Panel has been established to prepare a list of 25 substances for a Second Priority Substances List (PSL2) to be released in fall 1995. The following chemicals identified by Solv-Ex are listed on the draft working list of the PSL2:

- Alum (Aluminum ammonium sulphate or Potassium ammonium sulphate) as aluminum and compounds,
- Diesel or Diesel exhaust emissions,
- Gasoline,
- Natural gas (methane),
- Sulphuric acid,
- Al,
- Co,
- Cu,
- P,
- V, and
- Zn.

A list of Toxic Substances and Prohibited Substances are published as Schedules I and II, respectively to CEPA.

2.2.3 *Atmospheric Sources and Emissions*

The operation of the co-production plant will result in a number of sources that vent gases or particulate emissions into the atmosphere. If left uncontrolled, these emissions could have a deleterious effect on the environment. For this reason, the operation of these sources is controlled under the Alberta Environmental Protection and Enhancement Act (AEPEA) and its associated regulations.

Table 2.7 Chemicals that may be used in the proposed plant facility.

Item		Annual Consumption
1	Activated carbon	230 tonnes
2	Alum	310 tonnes
3	Caustic sods	2240 tonnes
4	Chlorine	250 kilograms
5	Corrosion inhibitor	2560 kilograms
6	DEA (allowance)	1000 kilograms
7	Demulsifiers	100 tonnes
8	Diesel fuel (Mine operation only)	4 978 710 litres
9	Flocculant	710 tonnes
10	Foam retardant (allowance)	1000 kilograms
11	Gasoline (Mine operation only)	382 250 litres
12	Glycol	100 cubic metres
13	Industrial degrasser (Allowance)	
	13.1 Action 705	2000 litres
	13.2 Action 706	2000 litres
	13.3 Belzona 9111	2000 litres
	13.4 Belzona N.F. Cleaner/Degrease	2000 litres
	13.5 CC22	2000 litres
	13.6 CC3915	2000 litres
	13.7 CC3919	2000 litres
	13.8 Citrosol	2000 litres
	13.9 Dearsol 71	2000 litres
	13.10 Formula FC 1160	2000 litres
	13.11 Formula FC 1161	2000 litres
	13.12 LiftOff Extra	2000 litres
	13.13 Penmut R-960 (Formula 2067)	2000 litres
	13.14 Power Wash	2000 litres
	13.15 Traxol	2000 litres
	13.16 Westicide	2000 litres

Table 2.7 Concluded.

Item			Annual Consumption	
14	Laboratory chemicals and reagents (Allowance)			
	14.1	1,1, 1-Trichloroethane	100	litres
	14.2	20 wt % NaOH	500	litres
	14.3	Acetic acid	100	litres
	14.4	Benzene	200	litres
	14.5	Dimethyldichlorosilane	100	litres
	14.6	Hydrochloric acid	50	litres
	14.7	Isopropyl alcohol	220	litres
	14.8	Methyl ethyl ketone	100	litres
	14.9	Nitric acid	50	litres
	14.10	Pentane	100	litres
	14.11	Sulphuric acid (reagent grade)	100	litres
	14.12	Tetrahydrofuran	100	litres
	14.13	Toluene	2000	litres
	14.14	Trichlorethylene	100	litres
	14.15	Varsol	500	litres
	14.16	100 mg/L stock solution of Ag	5	litres
	14.17	1000 mg/L Yttrium solution	5	litres
	14.18	100 mg/L stock of Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Sn, Si, Ti, V, Zn, Zr	5	litres each
15	Natural Gas (Processing plant only)		200	million N cu. m.
16	Sulphur		12 600	tonnes

2.2.3.1 Identification of Sources

Phase I of the project involves the mining extraction and upgrading of the bitumen. Process heaters, power and steam generation and sulphur recovery operations will produce emissions to the atmosphere. Approximately one year later, Phase II will be built to process the dry tailings and recover minerals. The additional process heaters, and power and steam generation will produce air emissions. Emissions from both phases include stationary (process vents and stacks) and mobile (construction and operating fleet) sources.

The relative locations of the major process areas and stationary emission sources are identified in the Phase II plot plan (Figure 2.13) and the contaminants associated with each source are identified in Table 2.8. Most of the emissions are associated with the venting of the products of fuel combustion to the atmosphere. There are two potential sources of fuel for the facility: Diesel oil (fuel oil No. 2) or natural gas. The most likely fuel is diesel oil. Combustion of diesel oil will result in SO_2 emissions in addition to NO_x and particulate generation. The emissions identified in Table 2.8 are based on the combustion of diesel oil. For either fuel case, the soaker/upgrader (stream A3) will burn fuel gas that is produced on-site.

Table 2.9 provides the dimensions of the major buildings on the plant site for Phase II, which includes the process areas for Phase I. The proposed building dimensions were taken from the process flow diagrams to be used in the dispersion modelling to account for the effects of building downwash.

2.2.3.2 SO_2 Emissions

Normal and Abnormal Emissions

The primary sources of SO_2 emissions are the sulphur plant (Phases I and II) and the acid plant (Phase II). Selected gas stream compositions and characteristics are given in Table 2.10. Figure 2.14 provides the block flow diagram of these sulphur-containing streams. For the Phase II operations, the sulphur plant and acid plant streams will be combined and vented through a common stack. Secondary sources of SO_2 include the process heaters and power boiler stacks resulting from the combustion of diesel oil that contains approximately 0.3 wt. % of sulphur.

Tables 2.11 and 2.12 present the Phase II stack parameters and emissions associated with the two fuel scenarios. The acid gas scrubber stream contains about 65% of the total sulphur to be emitted from the facility at a relatively low temperature of 50°C. To take advantage of the heating capability of the incinerator, the incinerator combustion gases will be heated to a higher-than-normal temperature to compensate for the relatively low scrubber stream temperature and then the two streams will be combined into a single stack. This minimizes the number of tall stacks on site and potentially conserves energy. The INCWRD incinerator model (Western Research & Development 1975) and combustion calculations were used to confirm H_2S destruction and to estimate SO_2 emissions and parameters for the combined stack.

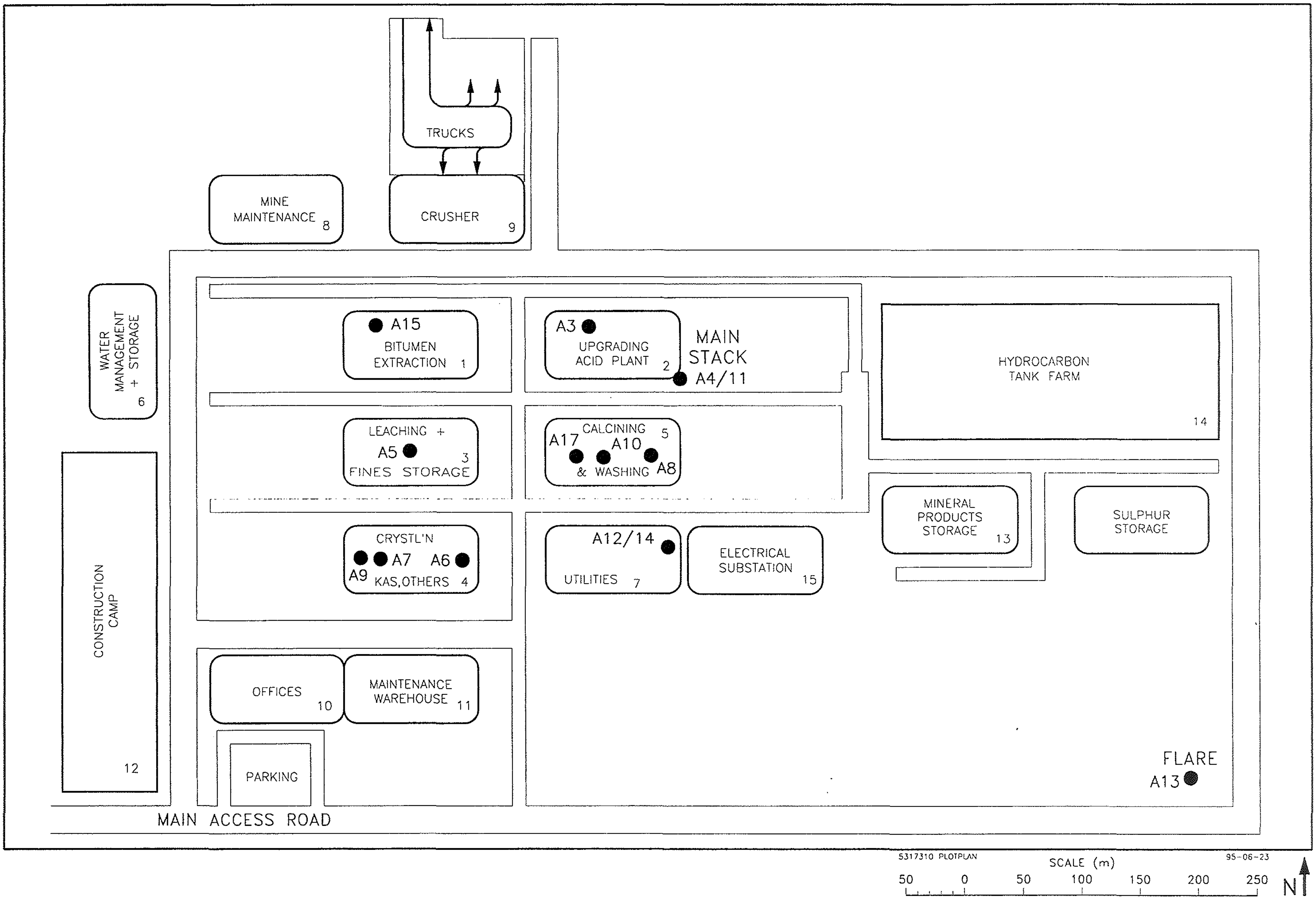


FIGURE 2.13 LOCATION OF EMISSION SOURCES

Table 2.8 Sources of SO_2, NO_x, particulates and CO_2 from Phase I and Phase II of Solv-Ex project.

Pollutant	SO_2		NO_x	Particulates	CO_2
	Fuel Oil	Natural Gas			
PHASE I					
Stationary					
A4 Sulphur plant incinerator	√	√	√	--	√
A12 Steam boiler/turbines	√	--	√	--	√
Total	2	1	2	0	2
Mobile					
Construction vehicle fleet	--	--	√	√	√
A12 Steam boiler/turbines	--	--	√	√	√
Total	0	0	2	2	2
PHASE II					
Stationary					
A4 Sulphur plant incinerator	√	√	√	--	√
A12 Steam boiler/turbines	√	--	√	--	√
A7 $FeSO_4$ dry flue gas	√	--	√	--	√
A9 $FeSO_4$ dry process	--	--	--	√	--
A10 K_2SO_4 dryer flue gas	√	--	√	--	√
A17 K_2SO_4 dryer process	--	--	--	√	--
A3 Soaker upgrader[(a)]	--	--	√	--	√
A6 Double salt dryer bag house	√	--	√	√	√
A15 Fines dryer flue gas	√	--	√	--	√
A5 Fines dryer venturi	√	--	--	√	--
A11 Acid Plant Scrubber	√	√	--	--	√
A8 Alumina dryer scrubber	--	--	√	√	√
A19 By-product sulphate dryer	--	--	--	√	--
Total	8	2	8	7	9
Mobile					
Construction vehicle fleet	--		√	√	√
Operating vehicle fleet	--		√	√	√
Total	0		2	2	2

"--" indicates zero or negligible source.

(a) Combusts only fuel gas from upgrader.

Table 2.9 Plant site building dimensions: Phase I and Phase II.

Process Area and Plot Plan Ref. No.[a]	Dimensions (m)			
	Length	Width	Peak Height	Phase
1. Extraction Plant	105	30	35	I, II
2. Upgrading Plant	75	20	15	I, II
3. Leaching and Fines Storage	65	15 to 24	23	II
4. Crystallization	120	15	10	II
5. Calcining and Washing	60	30	13	II
6. Water Storage	20	10	5	I, II
7. Utilities	75	25	8	I, II
8. Mine Maintenance	75	30	15	I, II
9. Crusher	N/A	-	-	I, II
10. Office	30	15	5	I, II
11. Warehouse	30	40	8	I, II
12. Camp	20	60	8	I, II
13. Product Storage	40	40	15	II
14. H/C Tank Farm	200	100	20	I, II
15. MCC / Substation	40	40	8	I, II

(a) Number corresponds to the process area shown in Figure 2.12.

Table 2.10 Gas stream compositions and properties: Normal operation.

Component (mol %)	Amine Plant Inlet[a]	Acid Gas to Sulphur Plant	Fuel Gas[b]		Waste Gas to Incinerator[c]	Acid Plant Scrubber Outlet
			On-Site	Pipeline		
O_2	0.00	-	0.00	0.00	0.00	1.43
H_2	2.35	-	3.06	0.00	0.00	0.00
He	0.00	-	0.00	0.00	0.00	0.00
N_2	0.00	-	0.00	0.35	64.05	89.48
CO_2	0.81	3.47	0.00	2.45	1.22	8.93
H_2S	22.55	96.53	0.00	0.00	0.68	0.00
H_2O	4.30	-	5.61	0.00	34.04	0.00
SO_2	0.00	-	0.00	0.00	0.00	0.16
C_1	27.98	-	36.51	96.59	-	-
C_2	16.08	-	20.98	0.32	-	-
C_3	12.07	-	15.75	0.24	-	-
iC_4	5.50	-	7.18	0.03	-	-
nC_4	1.84	-	3.15	0.02	-	-
iC_5	0.00	-	0.00	0.00	-	-
nC_5	1.20	-	1.57	0.00	-	-
C_{6+}	4.75	-	6.19	0.00	-	-
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Exit Temperature (°C)	-	-	-	-	50	260
Flow Rate (kg/sh)	2847.1	696.7	2150.0	n/a	3369.2	55 540.0
Molecular Mass (kg/kmol)	33.3	34.4	32.7	16.9	24.8	28.8

(a) Amine system inlet from the bitumen upgrader/fractionator.

(b) On-site gas is generated from the amine system; pipeline originates from Fort McMurray #1 Gate.

(c) As supplied to the Claus plant tail gas incinerator

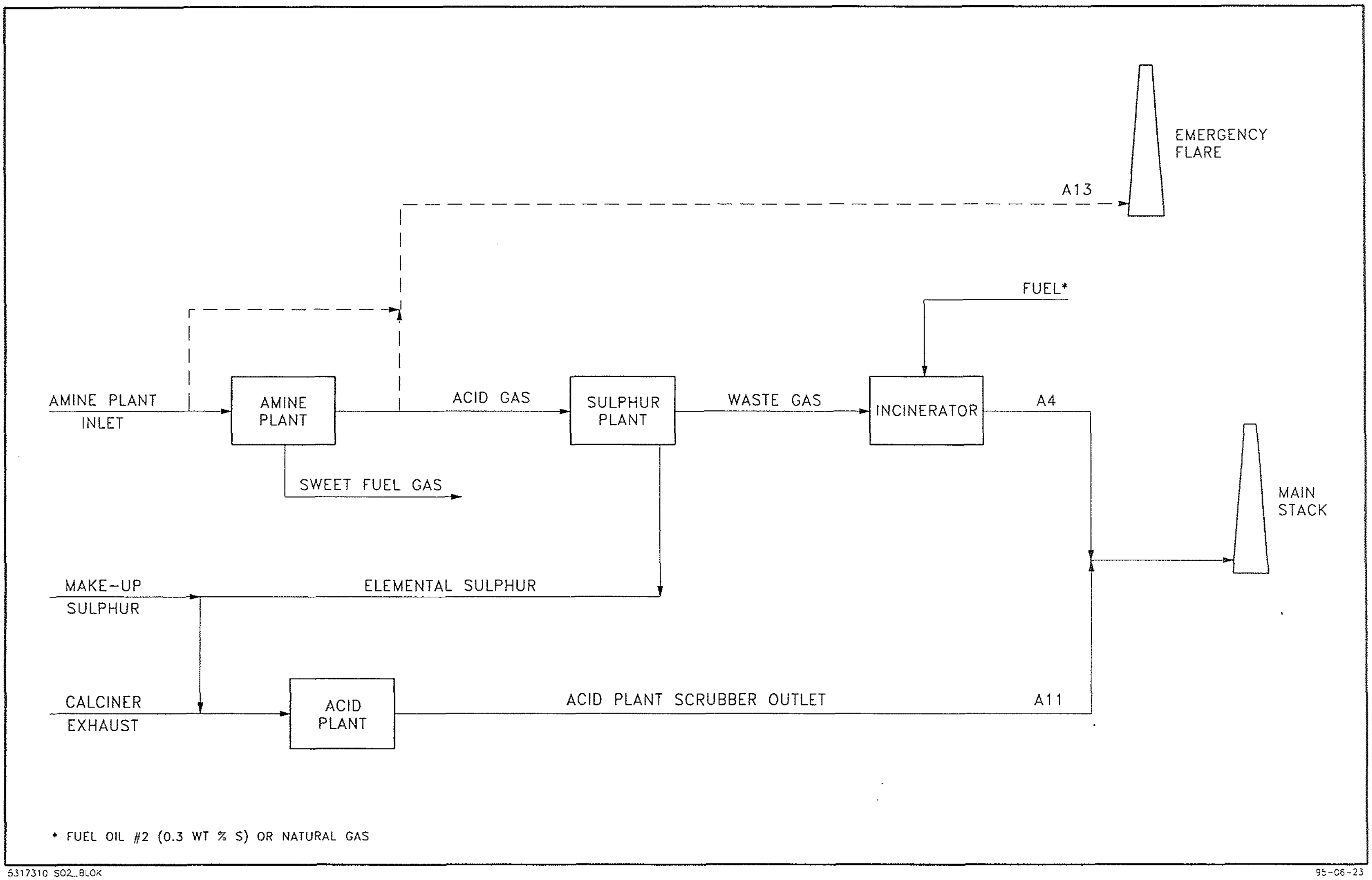


FIGURE 2.14 BLOCK DIAGRAM OF POTENTIAL SO_2 SOURCES

Table 2.11 Stationary SO_2 and NO_x sources: Diesel oil.

Source	Combined Abnormal A4/11[a]	Combined Normal A4/11[a]	$FeSO_4$ Dryer A7	K_2SO_4 Dryer A10	Power Boiler A12	Soaker Upgrader A3	Dbl Salt Dryer A6	Fines Dryer A15	Alumina Dryer A8[e]	Total[d]
Building Influence Height (m)	15	15	23	20	13	15	35	35	20	--
Stack Height (m)	60	60	35	33	33	38	53	53	33	--
Stack Exit Diameter (m)	1.35	1.35	0.2	0.2	1.6	1.2	1.5	0.9	0.6	--
Stack Exit Temperature (°C)	250	250	230	230	230	230	200	230	99	--
Stack Exit Velocity (m/s)	19.95	19.95	15.58	14.42	17.39	12.45	16.69	14.22	12.36	--
Fuel Oil Consumption[b] (m^3/d)	11.13	11.26	1.92	1.78	125.71	53.32[c]	93.91	32.45	17.07	334.68
Energy Input (GJ/h)	18.04	18.27	2.85	2.63	203.94	81.98[c]	152.36	52.65	27.69	542.37
SO_2 Emission Factor (ng/J)	131	131	131	131	131	0	131	131	131	--
SO_2 Emission Rate (g/s)	97.46	69.87	0.10	0.09	7.42	0.0	5.54	1.92	1.00	85.94
SO_2 Emission Rate (t/sd)	8.43	6.02	0.01	0.01	0.64	0.0	0.48	0.17	0.09	7.42
NO_x Emission Factor (ng/J)	61	61	61	61	43	61	43	61	61	--
NO_x Emission Rate (g/s)	0.31	0.31	0.05	0.05	2.47	1.38	1.84	0.90	0.47	7.47
NO_x Emission Rate (t/sd)	0.03	0.02	0.0	0.0	0.21	0.12	0.16	0.08	0.04	0.65

[a] "Combined" includes the emissions from the incinerator, acid plant and the combustion of the fuel oil.
[b] Fuel oil No. 2 (distillate oil) with a gross heating value of 38.9 GJ/m^3 and 0.3 wt% sulphur.
[c] Combusts only fuel gas produced on site. Included in total fuel as equivalent oil.
[d] The total flow rate and temperature has increased from the original model input but does not affect the contaminant emission rate.
[e] Total is the sum of normal emissions from the combined A4/11 stream plus the other stationary sources.

Table 2.12 Stationary SO_2 and NO_x sources: Natural gas.

Source	Combined Abnormal A4/11[a]	Combined Normal A4/11[a]	$FeSO_4$ Dryer A7	K_2SO_4 Dryer A10	Power Boiler A12	Soaker Upgrader A3	Dbl Salt Dryer A6	Fines Dryer A15	Alumina Dryer A8	Total[d]
Building Influence Height (m)	15	15	23	20	13	15	35	35	20	--
Stack Height (m)	60	60	35	33	33	38	53	53	33	--
Stack Exit Diameter (m)	1.35	1.35	0.2	0.2	1.6	1.2	1.5	0.9	0.6	--
Stack Exit Temperature (°C)	250	250	230	230	230	230	200	230	99	--
Stack Exit Velocity (m/s)	19.95	19.95	15.58	14.42	17.39	12.45	16.69	14.22	12.36	--
Fuel Consumption[b] ($10^3 m^3/d$)	11.73	11.88	1.81	1.72	132.44	53.32	99.09	34.24	18.01	325.51
Energy Input (GJ/h)	18.02	18.27	2.85	2.63	203.94	81.98	152.36	52.65	27.69	542.37
SO_2 Emission Factor (ng/J)	n/a	n/a	0	0	0	0	0	0	0	--
SO_2 Emission Rate (g/s)	96.83	69.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.17
SO_2 Emission Rate (t/sd)	8.37	5.98	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.98
NO_x Emission Factor (ng/J)	61	61	43	43	86	86	86	61	61	--
NO_x Emission Rate (g/s)	0.31	0.31	0.03	0.03	4.87	1.96	3.64	0.90	0.47	12.21
NO_x Emission Rate (t/sd)	0.03	0.03	0.0	0.0	0.42	0.17	0.31	0.08	0.04	1.06

[a] "Combined" includes the emissions from the incinerator, acid plant and the combustion of the fuel gas.
[b] Fuel gas with a gross heating value of 36.9 MJ/m^3.
[c] Combusts only fuel gas produced on site.
[d] Total is the sum of normal emissions from the combined stream plus the other stationary sources.

During normal operations, the SO_2 emission from the sulphur plant incinerator is approximately 0.059 tonnes per stream hour (t/sh) for both phases. For Phase II, the exhaust from the acid plant will contribute an additional 0.190 t/sh under normal operating conditions for a combined total of 0.249 t/sh (5.98 t/sd). Other contributors to SO_2 emissions under normal operation include the process heaters and power boilers, adding 0.060 t/sh (1.44 t/sd) for the fuel oil scenario. For the natural gas scenarios, the SO_2 emissions associated with these other sources is negligible. The SO_2 emissions for normal and abnormal operating conditions are as follows:

SO_2 Source		Phase I Emission Rate		Phase II Emission Rate	
		Normal	Abnormal	Normal	Abnormal
Incinerator[(a)]	(t/sh)	0.059	0.083	0.059	0.083
Acid Plant[(a)]	(t/sh)	0.000	0.000	0.190	0.266
Others[(b)]	(t/sh)	0.002	0.002	0.060	0.060
Total	(t/sh)	0.061	0.085	0.309	0.409
Daily Equivalent	(t/sd)	1.47	2.04	7.42	9.82

(a) Combined into a common stack.
(b) Assumes diesel oil.

Abnormal emissions from the two primary sources are expected to be 0.083 and 0.266 t/sh, respectively, for a combined upset SO_2 emission of 0.349 t/sh (this is equivalent to 8.4 t/sd). These emissions are based on a safety factor of 1.4 that accounts for hour-by-hour fluctuations in the process. The 8.4 t/sd value assumes a simultaneous upset in both the acid plant and the sulphur recovery plant. Upsets of this type are not expected for more than a few hours before corrective action is taken. The previous table compares the SO_2 emissions associated with these abnormal scenarios to the normal emissions.

Emergency Flaring

The Solv-Ex facility design includes a high-pressure flare header system that is designed to handle numerous situations, for example: to relieve temporary over-pressure in the plant processes, to allow de-pressuring of a given process for maintenance or in an emergency, or to blow down the entire facility in the event of an upset condition. The gas discharged to this header passes through an underground tank to allow free liquids to drop out before entering the flare stack. The flare stack is equipped with a continuously-burning pilot.

There are two main gas streams containing sulphur compounds that could be vented to atmosphere in an emergency (refer to Figure 2.14):

- If problems arise in the operation of the amine plant, the amine plant inlet gas from the bitumen upgrading process may have to be diverted to flare. This stream contains an equivalent of 30.1 t/d of SO_2 (as H_2S) with a high heating value as a result of the hydrocarbon content.

  Further downstream, the acid gas inlet to the Claus sulphur plant contains the same amount of sulphur equivalent, however, the hydrocarbons have been removed in the amine process resulting in a flow with a much lower heating value. Problems in the Claus operation may require this stream to be sent to the flare temporarily. The high H_2S content provides enough heat to meet the minimum 9 MJ/m^3 requirement for Alberta (Alberta Environment 1988).

The characteristics of the gas streams associated with flaring and the flare stack parameters are provided in Table 2.13. While the frequency and duration of events at the flare stack are not known, it is anticipated that both will be low. This means the flaring events described could typically occur from a few times per month during plant start-up to a few times per year during normal operations. Flaring events are expected to be less than a few hours in duration.

2.2.3.3 NO_x Emissions

Combustion of either diesel oil or natural gas will result in combustion products containing oxides of nitrogen (NO_x) being vented to the atmosphere. Oxides of nitrogen are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). During combustion, the primary NO_x component that is formed is NO and chemical reactions within the stack and the atmosphere result in the conversion to NO_2.

As NO_x emissions result from combustion processes, the amount of NO_x emissions will be proportional to the amount of fuel used. An estimate of the energy requirements for the mine and other process streams is given in Table 2.14.

Stationary NO_x Sources

Stationary NO_x emissions were identified on Tables 2.11 and 2.12 for the two fuel scenarios. Maximum NO_x emissions are associated with Phase II operations due to the increased number of sources. NO_x emissions associated with the combustion of diesel oil are lower than those associated with the combustion of natural gas.

Fuel to the heaters was based on an average thermal efficiency of 85% for the heaters and boilers. Using a material and energy balance, exit conditions were determined for each heater stack. The exhaust stacks were sized to produce reasonable exit velocities and heights to reduce downwash effects. NO_x emission factors were taken from the U.S. EPA (AP-42) standards. Emissions are based on 100% utilization. The eight NO_x sources at this facility produce a maximum of 12.21 g/s

Table 2.13 Emergency flare stack emission parameters.

Parameter		Amine Plant Inlet	Acid Gas
Gas flow rate	($10^3 m^3$/sd)	49.28	11.51
Sulphur equivalent	(t/sd)	15.07	15.07
Heating value	(MJ/m^3)	53.17	21.15
SO_2 emission	(t/sd)	30.10	30.10
SO_2 emission	(g/s)	348.43	348.43
Exit temperature[(a)]	(K)	1273	1273
Exit velocity[(a)]	(m/s)	20.0	20.0
Stack height	(m)	45.0	45.0
Effective height[(a)]	(m)	53.67	47.78
Stack diameter	(m)	0.241	0.241
Pseudo diameter[(a)]	(m)	1.784	0.544

(a) Pseudo diameter and effective release height are based on heat release from Brode's method (1988) (55% radiation loss, 45° flame angle). Temperature and velocity are assumed as 1000°C and 20 m/s.

Table 2.14 Estimated energy requirements for Phase I and Phase II construction and operating periods.

		Phase I	Phase II
CONSTRUCTION PERIOD			
Mining			
Mobile fleet	Diesel (L/a)	1 244 680	*--complete--*
	Gasoline (L/a)	95 570	*--complete--*
	Duration:	13 months	*--complete--*
Processing plant			
Operations[a]	Diesel (L/a)	622 340	311 170
	Gasoline (L/a)	47 785	23 893
	Duration:	9 months	6 months
OPERATING PERIOD			
Mining			
Mobile fleet	Diesel (L/a)	4 978 710	4 978 710
	Gasoline (L/a)	382 250	382 250
	Commencing:	1Q 1996	*--continuing--*
Processing plant			
Operations[b]	Diesel Oil (L/h)	8 933	19 795
	Or		
	Natural gas (m^3/h)[c]	9 425	20 885
	Commencing:	3Q 1996	*--continuing--*

[a] Estimated by Solv-Ex as one-half and one-quarter of the mine construction usage in Phases I and II, respectively.

[b] Fuel will be diesel oil; optionally process will use natural gas brought in by pipeline.

[c] As equivalent to the fuel oil based on process heat requirements.

or 1.06 t/sd of NO_x emissions (for the natural gas scenario). For the diesel oil scenario, the NO_x emissions are reduced to 7.47 g/s and 0.65 t/sd, respectively. The products of combustion from the calciner (rotary kiln) are included with the combined A4/A11 stream in the main stack.

Optionally, a gas turbine unit may be selected to partially replace the high-pressure boiler system to produce electricity plus high-pressure steam from natural gas. The emissions from the boilers without this turbine are larger than those associated with this optional case. For the purposes of being conservative, the emissions associated with this optional case are not presented and those associated with the high pressure boilers are used.

Mobile NO_x Sources

Mobile source emissions were estimated using emission factors of 15 g NO_x/hp-h (1512 ng NO_x/J) and 6.9 g NO_x/hp-h (699 ng NO_x/J) for diesel and gasoline, respectively. This factor is representative of heavy equipment (U.S. EPA AP-42, Vol. II, Sections 7.1 and 7.2).

During **operations**, the anticipated NO_x emissions from the mobile fleet are 0.73 t/d for both phases on a continuous basis. Throughout the operating life of the facility, there will be off-site traffic associated with transportation of the crude oil, minerals, workers and supplies. An estimate of the contribution of NO_x by these vehicles amounts to an additional 0.22 t/d for a total of 0.95 t/d for the mobile sources.

During the **construction period**, total NO_x emissions from natural gas, diesel and gasoline combustion are estimated to be as follows:

Construction Area		Phase I	Phase II
Mining	(t/d)	0.19	--constr. complete--
Process	(t/d)	0.09	0.03
Total	**(t/d)**	**0.28**	**0.03**
Total	**(tonnes)**	**97.3**	**8.3**

During Phase I construction, the NO_x emission rate associated with mobile sources are about 30% of those associated with the normal mobile operations. During Phase II construction, the corresponding NO_x emissions are about 3% of those associated with the normal mobile operations.

2.2.3.4 Particulate Emissions

Particulate emissions are associated with two types of sources: stack emissions and fugitive sources. Fugitive sources include wind-borne dust from the plant area, mine area, haul roads and dyke systems. There are also particulate emissions associated with the heavy mining equipment and vehicles.

Stationary Particulate Sources

The mineral extraction and salt dryer facility exhausts contain a small amount of fine particulates that are not completely removed by the recovery systems (venturi, electrostatic precipitator, etc.). In accordance with the Air Emissions Regulation (AEPEA, 124/93), none of these sources will contribute more than 0.20 grams of particulate per kilogram of total effluent.

Tables 2.15 and 2.16 summarize the particulate emissions for Phase II for both combustion scenarios. The maximum particulate emissions are associated with Phase II operations due to the larger number of sources. Lower particulate emissions are associated with the combustion of natural gas (0.74 t/d) than from the combustion of fuel oil (0.88 t/d).

Mobile Particulate Sources

Mobile combustion source emissions were estimated using an emission factor of 135 ng particulates/J of diesel fuel and 44 ng/J of gasoline. These factors are representative of heavy equipment (U.S. EPA AP-42, Vol. I, Table 3.3-2, dated 4/93).

During **operations**, the estimated continuous emission of particulates in combustion exhausts is 0.07 t/d for both phases. As for NO_x, the traffic to and from the site throughout the project can contribute additional particulates to the atmosphere. This figure is estimated to be 0.02 t/d, for a project total of 0.09 t/d.

During **construction**, the vehicles will consume gasoline and diesel fuel, both sources of particulate emissions. The total estimated emission rates from the mine and process area construction vehicle exhausts are as follows:

Construction Area		Phase I	Phase II
Mining	(t/d)	0.018	--constr. complete--
Process	(t/d)	0.013	0.010
Total	**(t/d)**	**0.031**	**0.010**
Total	**(tonnes)**	**10.7**	**1.8**

The particulates released during Phase I construction are approximately 34% of those associated with the mobile sources during normal operations. Phase II construction emissions represent approximately 11% of normal operating particulate emissions.

Particulate emissions from fugitive wind borne sources such as plant area, mine area, haul roads and dyke systems were not estimated.

Table 2.15 Stationary particulate sources: Diesel oil.

Source:	Venturi Scrubber A5	Dbl Salt Dryer A6	Alumina Dryer A8	$FeSO_4$ Dryer A9	K_2SO_4 Dryer A17	Power Boiler A12	Sulphate Dryer A19	Total[b]
Building Influence Height (m)	23	35	20	23	20	13	23	
Stack Height (m)	35	53	33	25	33	33	25	
Stack Exit Diameter (m)	1.2	1.5	1.0	0.2	0.2	1.6	0.8	
Stack Exit Temperature (°C)	80	200	80	80	80	230	100	
Stack Exit Velocity (m/s)	17.67	16.69	16.69	12.47	11.86	17.39	17.25	
Effluent Mass Flow Rate (kg/h)	54 620	101 560	38 865	1220	1160	217 348	19 247	
Fuel Oil Consumption[a] (m^3/d)	n/a	93.91	17.07	n/a	n/a	125.71	n/a	
Energy Input (GJ/h)	n/a	152.36	27.69	n/a	n/a	203.94	n/a	
Particulate EmissionFactor (ng/J)	[b]	[b]	[b]	[b]	[b]	43	[b]	
Particulate Emission Rate (g/s)	3.03	5.64	2.16	0.07	0.06	2.44	1.07	**14.47**
Particulate Emission Rate (t/d)	0.26	0.49	0.19	0.01	0.01	0.21	0.09	**1.25**

(a) Diesel oil (distillate oil) with a gross heating value of 38.9 GJ/m^3.
(b) Emission according to AEPEA guideline 124/93 Part 2 8(1)(b) of 0.2 g particulate/kg effluent.

Table 2.16 Stationary particulate sources: Natural gas fuel.

Source	Venturi Scrubber A5	Dbl Salt Dryer A6	Alumina Dryer A8	$FeSO_4$ Dryer A9	K_2SO_4 Dryer A17	Power Boiler A12	Sulphate Dryer A19	Total
Building Influence Height (m)	23	35	20	23	20	13	23	
Stack Height (m)	35	53	33	25	33	33	25	
Stack Exit Diameter (m)	1.2	1.5	1.0	0.2	0.2	1.6	0.8	
Stack Exit Temperature (°C)	80	200	80	80	80	230	100	
Stack Exit Velocity (m/s)	17.67	16.69	16.69	12.47	11.86	17.39	17.25	
Effluent Mass Flow Rate (kg/sh)	54 620	101 560	38 865	1220	1160	217348	19 247	
Fuel Consumption[(a)] ($10^3 m^3/d$)	n/a	99.09	18.01	n/a	n/a	132.44	n/a	
Energy Input (GJ/h)	n/a	152.36	27.69	n/a	n/a	203.94	n/a	
Particulate EmissionFactor (ng/J)	[(b)]	[(b)]	[(b)]	[(b)]	[(b)]	13	[(b)]	
Particulate Emission Rate (g/s)	3.03	5.64	2.16	0.07	0.06	0.74	1.07	**11.70**
Particulate Emission Rate (t/sd)	0.26	0.49	0.19	0.01	0.01	0.02	0.09	**1.01**

(a) Fuel gas with a gross heating value of 36.9 MJ/m^3.
(b) Emission according to AEPEA guideline 124/93 Part 2 8(1)(b) of 0.2 g particulate/kg effluent.

2.2.3.5 CO_2 Emissions

In designing the processes employed in mining the oil sands, extracting the bitumen, upgrading the bitumen and processing the tailings to recover salable minerals, Solv-Ex has made efforts to reduce overall energy requirements, thereby reducing CO_2 emissions resulting from combustion. Some examples include:

- Internal recycle of process water,
- Waste heat recovery exchangers on all applicable streams to generate low pressure steam,
- Pre-heat process streams with waste heat, and
- Steam and power generation optimization.

Continuous sources of CO_2 during the **operating period** include the primary stack (sulphur plant incinerator and acid plant), secondary stacks (flare, boiler, power generation package, process heaters) and the mobile fleet exhausts. The CO_2 generated by the calciner (rotary kiln) is included in the A11 acid plant stream. Under the current design, all of the natural gas produced on site will be consumed by the soaker upgrader. For purposes of this evaluation, all energy needs in excess of the produced fuel will be assumed to be met with natural gas or fuel oil. Operations and mining vehicles were assumed to be powered by diesel fuel and gasoline.

An estimate of Phase I and II total stationary and mobile CO_2 emissions is provided in Table 2.17 for both fuels. Of the total 1161 t/sd (Phase II) of estimated CO_2 emissions, approximately 29% are associated with the steam boiler (A12) stack. The acid plant scrubber (A11) contributes approximately 21% of the total. If the facility were to combust natural gas in place of diesel fuel, the total CO_2 emissions from the total facility would decrease to about 1002 t/sd.

The continuous **mobile source** release of CO_2 to the atmosphere has been estimated at 40.7 t/sd for both phases. This was calculated by applying an emission factor of 3.19 kg CO_2/kg diesel and 3.15 kg CO_2/kg gasoline to the total estimated fuel consumption for the mobile fleet as described in Table 2.15. The off-site traffic will also contribute to the total CO_2 release to the atmosphere. This is estimated to be 4.6 t/a, for a total project CO_2 generation of 14 846 t/a (40.7 t/d).

During the **construction period**, release of CO_2 for the two phases has been estimated as follows:

Construction Area		Phase 1	Phase II
Mining	(t/d)	10.3	--constr. complete--
Process	(t/d)	5.5	2.7
Total	**(t/d)**	**15.8**	**2.7**
Total	**(tonnes)**	**5494**	**492**

Table 2.17 Stationary[a] and mobile CO_2 sources.

Process ID	PHASE I CO_2 Emission Rate (t/sd)		PHASE II CO_2 Emission Rate (t/sd)	
	Natural Gas	Diesel Oil	Natural Gas	Diesel Oil
A7 $FeSO_4$ dryer	--not operating--		3.5	5.2
A10 K_2SO_4 dryer	--not operating--		3.4	4.8
A12 Steam boiler[b]	180.5	237.0	258.9	340.0
A3 Soaker upgrader[c]	72.7	72.7	104.2	104.2
A6 Double salt dryer	--not operating--		193.7	254.0
A15 Hot oil fines dryer	--not operating--		66.9	87.8
A11 Acid plant scrubber	--not operating--		248.1	248.1
A8 Alumina dryer	--not operating--		35.2	46.2
A4 Claus plant incinerator[d]	5.4	7.1	23.2	30.5
Mining and process **mobile** sources[c]	40.7	40.7	40.7	40.7
TOTAL	299.0	357	1003	1162

[a] All sources are rated at 100% load, operating continuously. Based on 1.955 kg CO_2/m^3 gas, and 2705 kg CO_2/m^3 oil consumed.

[b] Electrical and steam requirements will be met by either gas turbine or high-pressure steam. Only one of these units will be selected in the final design. For the gas turbine, Phase I is 64.9% of Phase II; for the high pressure boiler, Phase I is 69.7% of Phase II. Stream A12 includes the gases from the turbine in either case.

[c] Soaker burns only fuel gas; mobile sources burn only diesel and gasoline.

[d] Operating at normal conditions. The acid plant and incinerator streams are combined into a single stack in Phase II.

This is based on complete conversion of the fuel's carbon content to CO_2.

2.2.3.6 Odorous and Fugitive Emissions

The oil and gas industry handles many gaseous compounds which are detectable by odour. If an odour is objectionable, any quantity above the odour threshold can result in a complaint. The control of odours involves one or more of the following:

- Ensuring ambient concentrations are less than the odour threshold (e.g., vent gas stream through a stack),
- Preventing odourous compounds from entering the atmosphere (e.g., vapour recovery), and
- Conversion to a compound with a higher odour threshold (e.g., convert H_2S to SO_2).

All three methods have been used in the oil and gas industry.

Odours can result from controlled or fugitive emissions. Controlled emissions involve the release of gaseous compounds through a device that is specifically designed for that purpose (e.g., a stack or fume hood vent). Within a given processing facility all the controlled sources are identified and emissions from them may even be regulated. Fugitive emissions result from devices that are not designed to accommodate gaseous emissions and include leaks in piping, flanges, rotating seals; evaporation from process drains, holding ponds, spills, product handling and storage; and pressure relief valves. Fugitive sources tend to be small and potentially numerous and, as such, are particularly difficult to identify and quantify. Normally, fugitive emissions are controlled through good housekeeping, monitoring and maintenance procedures that minimize leaks and spills. For an oil sands mining and extraction facility, fugitive emissions can also result from the mine and tailings pond areas.

At the proposed Solv-Ex site, the areas which have been identified as potential fugitive emission sources of reduced sulphur compounds (e.g. H_2S) and hydrocarbons (HC) are:

- Mine (HC, H_2S),
- Bitumen processing and upgrading (HC, H_2S), and
- Amine and sulphur recovery plants (H_2S).

Due to the improved bitumen extraction process, the dry tailings are not anticipated to contribute as much to fugitive volatile HC or reduced sulphur compounds as Syncrude's or Suncor's tailings. A summary of the fugitive emissions anticipated from the Solv-Ex facility are given in Table 2.18. Applying a scaling factor for throughput and surface area of the Solv-Ex facility to a Syncrude study (Concord 1988), the approximate methane emission (C_1) from Solv-Ex is 2.8 g/s or 0.24 t/d. This assumes that roughly 10% of the total HC emissions are methane. A later study of Syncrude's tailings ponds (Concord 1992) revealed that the emissions were only about 12% of that originally determined. There was no significant change in the sulphur compound emissions

Table 2.18 Summary of fugitive emissions.

Source	Volatile Hydrocarbons[a]		Reduced Sulphur Compounds	
	(g/s)	(%)	(g/s)	(%)
Tailings Disposal Area[b]	15	63	0.07	88
Process Area[c]	8	33	-	-
Mine Area[d]	< 1	< 4	0.01	12
Total	24	100	0.08	100

[a] Defined as C_5 to C_{10} compounds. C_1 comprises approximately 10% of the total HC emissions and C_5 to C_{10} account for 86% of the total emissions.

[b] Solv-Ex's proposed tailings area is approximately 4.4% of Syncrude's at the time of the study (September, 1987).

[c] Solv-Ex's proposed production will be approximately 5.8% of Syncrude's at the time of the study (September, 1987).

[d] Solv-Ex's mine area will be approximately 7.3% of Syncrude's at the time of the study (September, 1987).

between the two studies. It can be reasonably expected that the HC emission from Solv-Ex will be less than predicted here.

2.2.3.7 Annual Emissions Summary

The extraction and upgrading process is expected to operate approximately 8000 h/a yielding a utilization factor of 0.913. For estimating annual emissions, this factor should be applied to the values for SO_2, NO_x, particulates and CO_2. It does not apply to the mobile sources on or off-site, or to the fugitive sources. Therefore, on an annual basis, emissions of these pollutants will be less than the totals given by approximately 9.5%. The following table summarizes the annual emissions:

Pollutant	**Emission Rate (t/a)**	
	Phase 1	**Phase II**
SO_2 [(a)]	490	2473
NO_x [(b)]	163	352
Particulates[(a)]	49	296
CO_2 [(a)]	120 000	388 000

(a) Assumes combustion of diesel oil.
(b) Assumes combustion of natural gas.

In the above estimate, the worst case fuel scenario was assumed using the operations phase.

2.2.3.8 Noise

Potential noise sources at Solv-Ex can be classified as either process or mobile. Within the process, conveyor systems, feed sizing and separating equipment, rotating equipment (pumps, fans, aerial coolers) and fired vessels will contribute to noise levels. Also on site, the vehicular traffic of operations and maintenance staff, suppliers and the trucks to and from the mine and plant crusher will generate noise. At the mine site, the heavy equipment associated with the removal of the overburden and excavation activities will contribute to the background sound levels.

With the exception of the loading and conveying equipment, the majority of the plant-site sources of noise will be housed within closed buildings and the enclosures should significantly attenuate the sound levels. Out-of-doors, the noise generated will primarily be from the aerial coolers and the oil sands conveyor system. Sound levels will be within the guidelines of the ERCB Noise Control Directive i.e., 40 dBA Leq (ERCB ID 94-4), in a 1.5 km radius from the proposed plant site. There are no residences closer than 15 km distance from the boundaries of the entire Lease

No. 5 and these should not be adversely affected by the noise generated on-site under normal conditions.

2.2.4 *Environmental Monitoring*

Environmental monitoring will be required during the life of the project. Two types of monitoring will be in effect:

- Compliance monitoring as required to meet license and related conditions as specified in the approvals used for the project: and,

- Biophysical monitoring using indicator species as required to meet non-permitted statutory requirements.

Monitoring programs will be designed for the Solv-Ex project based on discussions with Alberta Environmental Protection. They will monitor ambient air quality, water quality, waterflows and reclamation success.

Locations of ambient air monitoring equipment will be chosen based on modelling results and consultation with AEP. The following parameters are typically recorded during monitoring and this list will be finalized in consultation with AEP:

- Air temperature,
- Sulphur dioxide,
- Hydrogen sulphide,
- Oxides of nitrogen,
- Hydrocarbons,
- Ozone,
- Carbon monoxide,
- Static H_2S and total sulphation stations, and
- Wind speed and direction.

Water quality of effluent streams prior to discharge to be monitored will be defined in consultation with AEP.

The following parameters will be recorded at the shore-based water intake station on the Athabasca:

- Periods and rates of water withdrawal,
- Monthly quantities of water withdrawn, and
- Water surface elevation (Athabasca River).

Reclamation success will be monitored. Monitoring requirements for soil quality, revegetation success and overall compliance with annual schedules and indicator species or parameters will be determined through consultation with Alberta Environmental Protection as well as area stakeholders.

2.3 Reclamation Plans

2.3.1 *Conceptual Reclamation Plan*

Solv-Ex's reclamation objective is to re-establish a self-sustaining landscape that has a capability at least equivalent to that existing prior to land disturbance. Post-development landscape capability for forestry, wildlife and recreation will generally be similar to the original landscape. The replaced soils will be as capable as those of the original site, but the soils will be replaced into a predominantly well-drained landscape as opposed to the poorly-drained pre-disturbance landscape in the area of the plant. The vegetation types established will be similar to the pre-disturbance condition. The end land use for the disturbed areas will be developed by Solv-Ex in consultation with local stakeholders and AEP.

If the experimental project is discontinued after 2002, there will be an end-pit lake left in the mine of about 30 ha with 20 ha reclaimed to vegetation types compatible with the surrounding area. The rest of the plant and mine would be reclaimed to meet equivalent soil capabilities.

All facilities and equipment would be decommissioned and removed at abandonment as per AEUB requirements.

Reclamation of the mine area will begin in 1998 and will be phased during the operating period of the mine. The reclamation procedure will be to initially establish grass-legume mixtures on disturbed areas and then gradually establish forest vegetation. Reclamation planning will be phased with mine planning to ensure successful reclamation.

At the completion of the mining schedule, the unreclaimed mine area of approximately 30 ha will be left to create an end-pit lake. The reclaimed mine area of 20 ha will ultimately be revegetated to coniferous (15 ha), deciduous (3 ha) and mixedwood (2 ha) forests (Table 5.19). This will return approximately 60% of the current forest capability to the mine area.

After October 2002, reclamation of the plant site and associated facilities area (minus the mine site) will return a further 267 ha of land to productive forest. This will increase productive forest land for the total area (including the mine site) by approximately 400%. The forest communities replaced within the plant site and associated facilities area will include aspen (124 ha), mixedwood forest (121 ha) and coniferous forests of white spruce, jack pine and black spruce (22 ha).

Forest productivity will include the restoration of the mosaic of vegetation communities found within the disturbed areas prior to development. This includes the restoration of the shrub and herbaceous species contained within the white spruce, aspen and jack pine series of vegetation communities. This is intended to restore some of the ecosystem elements to the reclaimed area. Reforestation to meet Alberta Forest Service guidelines, is expected to take approximately 15 years, following which a reclamation certificate will be applied for.

2.3.2 *Reclamation Materials Handling*

Using mobile equipment, suitable reclamation materials (muskeg and selected overburden) will be stripped from pre-mine areas and selectively salvaged until reclamation can begin.

Solv-Ex is currently completing an inventory of the volumes of overburden, located within the undisturbed portions of the mine areas, that are suitable for reclamation. Solv-Ex will define the suitability of materials for reclamation using criteria developed by the Alberta Soils Advisory Committee (1987). Materials considered suitable for reclamation have a pH between 4 and 8, a salinity (electrical conductivity) < 4, a sodicity (SAR) of < 8, oil composition < 1% and a texture of sandy loam, loam, silt loam, silty clay loam, clay loam or sandy clay loam. Reclamation material salvage criteria for the Solv-Ex mining operation are:

- Minimum salvage depth of 0.5 m,
- Maximum salvage depth of 1.0 m,
- Maximum dilution with poor (but acceptable) quality material of 30%, and
- Salvage from areas subject to overburden stripping.

A minimum 100 000 m^3 of suitable overburden will be salvaged and stockpiled for reclamation for the mine within the 7 year experimental period. At the other disturbed areas (e.g. plant site) a minimum of 15 cm of suitable soil will be salvaged at these sites. Where muskeg is encountered, it will be salvaged and used as a reclamation amendment.

2.3.3 *Reclamation Methods*

Reclamation begins in 1998. Reclamation procedures include:

- Recontouring and ground preparation: to re-establish topography and drainage,
- Topsoil reconstruction, and
- Revegetation.

The above reclamation program will ensure that the land is returned to predevelopment capability levels. To maintain as many level areas as possible, the external tailings disposal area and external mine waste dump will be reclaimed in their natural form by recontouring to 20 to 30% slopes. Thicker muskeg topsoil will be replaced on the tailings disposal area and waste dump slopes than on the flat areas.

A bulldozer and grader will mix and spread the muskeg, tailings sand and glacial drift materials. For sloping areas, the muskeg will be mixed on top and pushed down the slope.

Reclaimed areas will be dressed with the appropriate soil nutrients, seeded and mulched. Grasses, trees and shrubs species will be planted that are compatible with the surrounding landscape, and methods to encourage native species invasion will be pursued.

A conceptual cross-section of the mine pit backfilling sequence is shown in Figure 2.5. Tailings management and reclamation is summarized in Section 2.2.2.1.

2.4 Public Safety

The codes, standards and regulations which have been identified as being applicable to the design of the plant and pertaining to safety considerations are as follows:

- Canadian Electrical Code,
- Alberta Regulations Electrical Protection Branch,
- Canadian Standards Association, and
- Occupational Health and Safety Regulations - Alberta.

The first three of the above relate to hazardous area classifications, electrical equipment specifications and installation standards, and the fourth relates to worker health, safety and compensation.

The co-production plant will be designed and operated according to the most stringent safety requirements and a comprehensive worker health and safety program will be developed and implemented. Workplace Hazardous Materials Information System (WHMIS) guidelines will be adopted. The handling of flammable liquid and corrosive liquids will be designed, where possible, with automatic prevention of conditions hazardous to life, health or property. The plant will be designed to make the emergency shutdown procedure simple, rapid and safe. Appropriate fire, emergency, and first aid facilities and training will be provided.

2.4.1 *Emergency Response and Contingency Plans*

The plant site is located in the Athabasca oil sands region of Alberta, Canada, approximately 85 kilometers north of Fort McMurray. Due to the remote location of the plant site, exposure and risk to the general public will be minimal, however, site security and safety regulations will be fully implemented at all times.

All plant personnel will be made familiar with emergency and contingency response procedures for:

- Containment and clean up of oil and chemical spills,
- Plant upset conditions,
- Fire prevention and suppression,
- Neutralizing acid spills within the containment area and diluting acid from floor washdown at the Acid Plant.

Solv-Ex will join the regional Oil Spill Co-op to work with other area operators in dealing with accidents. The transportation of all products such as PCO and minerals will be undertaken in accordance with Transportation of Dangerous Goods guidelines. Materials for spill clean-up will be maintained on-site.

In the event of plant upset conditions, i.e., the Acid Plant has to be shut down, sulphur dioxide and sulphur trioxide will be absorbed in $CaCO_3$ solution circulated through the scrubber. The tail gas from the scrubber will pass through an efficient mist eliminator before being exhausted to the stack.

2.4.2 *Fire, Explosion and Spill Prevention*

In the upgrader, the hydrocarbons present are typical for most refineries, and the same fire and explosion hazards exist as is typical for that industry. Other flammable materials that will handled include natural gas, laboratory reagents, and minor quantities of other combustible materials. The safe handling of these materials has been widely demonstrated in many industries. There are not problems arising from chemical reactions and spontaneous auto-ignition materials.

In the mineral extraction plant, the acid streams are typical of sulphuric acid plants and acid leaching in the mineral industries. There are no risks for fire and explosions. However, hazards derived from corrosive liquid handling are to be addressed.

The safety principles to be employed throughout the plant for preventing fires, explosions and spills include:

- Avoidance of flammable hydrocarbon-air mixtures near sources or ignition by using totally enclosed vessels and using plant equipment with an inert gas purge and/or hydrocarbon monitoring system,

- Avoidance of spillage's by containment of fluids in processing plant equipment and tanks by high standards of engineering, sealing systems, operation and maintenance. Provision for spillage containment, collection and recycling facilities will be an integral part of the design,

- Avoidance of potential sources of ignition by use of explosion proof electrical equipment and safe instrumentation; use of flame arrestors and lighting conductors; elimination of static electricity charges by grounding of conductive metals to earth, submerged filling and dip pipes; avoidance of non-conductive pipe materials, hot surfaces and frictional heat sources,

- Overall commitment to safety in the management, operation and maintenance of the facilities specifically targeted at the avoidance and control of all potential ignition sources; including non-smoking areas, hot working construction and maintenance operations, and the use of diesel engines protected for spark arrest, hot surfaces and induction shut off,

- Plant layout to allow adequate spacing between units and access for maintenance and firefighting, and

- Use of non-combustible and acid resistant materials of construction wherever practicable.

2.4.3 *Overpressure and Protection*

Overpressurization of plant equipment, vessels and storage systems could result from overheating, external fire or from pumping against a closed system.

All the closed atmospheric process equipment and vessels will be vented. Pressure relief devices will be provided, when necessary, to protect equipment items. These devices will include relief valves, rupture disks, or explosion panels as appropriate for each specific case. All positive displacement pumps will be fitted with pressure relief valves.

2.4.4 *Emergency Shutdown*

In a plant handling flammable hydrocarbons and corrosive liquid, it is essential that provision is made for safely shutting down the plant in an emergency. The emergency could be major spillage or a fire or injury which could lead to a worsening situation if operations continued.

Provisions will be made to effect the automatic shutdown of the individual processing units from the local control room, as well as for the entire plant from the control center. As part of the alarm instrumentation, abnormal process conditions (e.g., high/low levels, high temperature etc.) will be used to trigger automatic shutdown. Above all, the automatic shutdown will be capable of manual initiation.

As part of the emergency shutdown, the major equipment items and unit processes will be isolated by automatic valving as appropriate.

2.4.5 *Hazard Detection and Evaluation*

Automatic on-line detectors are recommended as follows:

- Fire detection throughout the entire facility,
- Hydrocarbon and corrosive fumes (SO_2, SO_3, H_2S, etc.) detection in the work place,
- Hydrocarbon-oxygen detection in the vapor vent system,
- Noise level detection in the vicinity of the source (if any), and
- Vibration detection for the centrifuges with automatic shutdown.

Hand operated explosion meters and gas detectors are required for safety, maintenance and vessel entry control. Magnetic slurry density/level transmitters should be checked for any leak emission by a suitable detector.

The application of a formal systematic critical examination of the process and engineering designs is required to assess the hazard potential of malfunction or maloperation of the individual units of the plant and the consequential effects on the whole facility. This evaluation will be used to identify the potential major hazards and a "check list" approach will be used to consider the general parameters (e.g., materials handled, unit operations, and plant layout) against lists of the potential hazards (e.g., fire, explosion, and corrosion). If major hazards are identified by this approach, fundamental decisions will then be made to alleviate the risk (e.g., location, design change, and safety instrumentation). The most convenient time for this evaluation is at the "design freeze" stage when the background thinking underlying the design is fresh and available.

2.4.6 *Monitoring and Operating Procedures*

Solv-Ex will implement material inventory control systems to monitor all inputs and outputs of the plant and mine. While this is standard industry practice, since this is an experimental facility, it is imperative to accurately monitor the performance of all aspects of the project in relation to expected outcomes. The monitoring results will be compared to key performance standards for the following:

- Bitumen recovery,
- Mineral recovery
- Dry tailings disposal, and
- Water utilization.

In the event that operational or equipment problems are encountered, the plant will be shut down to ensure that environmental protection and plant safety is maintained at all times. Plant start-up will occur once modifications have been made or new procedures introduced to ensure successful operation of the facilities.

2.4.7 *Emergency Contingency Planning*

It is the intent of Solv-Ex to provide and enforce a safe working environment for its project employees and the potentially affected public. Also, Solv-Ex will ensure that adequate emergency facilities and personnel (to meet generally acceptable industrial safety standards) will be available in to meet most situations. However, it is conceivable that a project related emergency could represent a concern for public safety. Due to the project's remoteness from human settlements, only a worst case scenario could eventuate in such a risk.

Our assessment is that a worst case would likely involve an accident during the transportation of hazardous goods such as chemicals to, or PCO from, the plant. The risk to public safety would likely be greatest in the extremely unlikely event that such an accident took place in close proximity to human habitation. The most sensitive location for this to take place would likely be where Highway #63 traverses the lower townsite at Fort McMurray. A spill into the Athabasca River or a fire/explosion near either commercial or residential developments could have serious consequences.

As mentioned above Solv-Ex will be members of the regional Oil Spill Coop and would call upon the substantial resources available to address that eventuality. In addition, the City of Fort McMurray has a Disaster Services Plan in place which has recently been put to the test to deal with the regional forest fire emergency. Solv-Ex will consult with the Emergency Services officials to ensure that any contingencies that may arise from the project have been anticipated and can be addressed. The risk of the worst case scenario presented is not substantially different from, and should be of smaller magnitude than, that related to existing oil sands operations. Solv-Ex, of course, will cooperate fully with any local/regional disaster response activities or programs.

2.4.8 *Traffic Control Procedures on Highway 63 and Mine Haul Road*

Solv-Ex will ensure that Highway 63 close to the plant and mining operations has clear signs to make motorists aware of the truck traffic from the plant and mine. A stop sign will be placed where the mine haul road crosses Highway 63. All truck operators will be trained in safe driving procedures.

3.0 PUBLIC PARTICIPATION AND CONSULTATION

Solv-Ex has had an ongoing Public Participation and Consultation Program since the Co-production Experimental Project was formally announced to the public on December 19, 1994. Public notice, as required under the Alberta Environmental Protection and Enhancement Act (AEPEA), was published in the following newspapers:

- Fort McMurray Today; January 23, 1995,
- Edmonton Journal; January 27, 1995,
- The Windspeaker; January, 1995,
- The Native News Network; January, 1995, and
- The Slave River Journal; January, 1995.

This section of the report outlines the meetings and summarizes the issues that were raised during the public consultation process, which is still ongoing.

3.1 Summary of Environmental Issues Raised at Public Meetings or In Response to Draft Terms of Reference, and Resolutions to Issues

A list of the meetings and contacts made by Solv-Ex from January 1995 to the present are included in Appendix II.

Written responses to the Draft Terms of Reference were received from the following individuals and organizations:

Date	Individual	Organization
February 7, 1995	Chief Mel Grandjamb	Fort McKay First Nation
February 16, 1995	Pat McInnes	Oil Sands Environmental Coalition
February 21, 1995	Chief Mel Grandjamb	Fort McKay First Nation
February 24, 1995	Brian Deheer	Alberta Wilderness Association
March 6, 1995[a]	Dan Smith	Pembina Institute which is part of Oil Sands Environmental Coalition
March 9, 1995[a]	Alexander McKenzie	Northern Lights Regional Health Authority 16

[a] Written responses were received after the February 28, 1995 deadline set by Alberta Environmental Protection for input by key stakeholders into the Terms of Reference.

Environmental issues raised in the written responses to the Draft Terms of Reference, or at the meetings held by Solv-Ex are listed below. In parentheses after each issue, the section(s) of the EIA that addresses the issue has been identified.

- **Socio-Economic Issues**

  - Employment opportunities available for Aboriginals (Section 9.2).
  - Company policy development in relation to co-management of the area with Aboriginals, trapper compensation, opportunities for Aboriginal job ventures, job training, Aboriginal content of direct work force and employment equity practices (Section 9.9).
  - Community consultation procedures (Section 3.0).

- **Air Quality and Noise**

  - SO_2 concentrations predicted in the area (Section 5.2.2).
  - Technology to be used to reduce air emissions (Section 2.2.3.5).
  - Type of monitoring programs that are planned (Section 5.2.8 covers ambient air quality monitoring).
  - Solv-Ex policy on joining the Regional Air Quality Committee (RAQC) (Section 5.2.8).
  - Cumulative effects of SO_2 emissions including the Syncrude and Suncor expansion projects. Impact of SO_2 emissions from facilities that refine PCO (Sections 5.2, 5.3.2.2, 5.5.2.1, 5.6.2, 5.7.1.3).
  - Transportation related emissions (Section 2.2.3.3).
  - Noise impacts (Section 5.2.6).
  - Particulate and heavy metal production (Section 5.2.5 discusses particulates).
  - Production of greenhouse gases including CO_2 and methane and from off-site and support facilities (Section 5.2.7.2).

- **Groundwater**

  - Potential impact of basal aquifer water on mining (Section 5.4.2).
  - Determine whether underground channels and fissures may be present around Lease 5 that could allow water movement from McClelland Lake (Section 4.5).

- **Reclamation**

  - Solv-Ex should use native species in reclamation of site (Section 2.3.3).
  - What is the chemical composition of the tailings (Section 2.2.2).
  - What are the expected land disturbance patterns (Section 1.2).
  - Identify and describe the presence of any medicinal plants used by Aboriginals (Section 4.9.4).

- Describe the size of reclamation bond Solv-Ex will provide to Alberta Environmental Protection to ensure the area is reclaimed (Section 1.5).
- Create a self-sustaining and biologically diverse system (Section 2.3.1).
- Re-establish forest or agricultural productive capacity (Section 2.3.1).
- Use receptor based monitoring to complement physical/chemical monitoring (Section 2.2.4).
- Use biological indicators of reclamation success (Section 2.2.4).

- **Setbacks**

  - Describe type of natural features at the site that are listed in the Draft Fort McMurray-Athabasca Integrated Resource Plan (Section 1.4).
  - Describe width of setback and rationale for the width chosen (Section 1.4).

- **Impact Assessment**

  - Undertake cumulative effects impact assessment for whole ecosystem (Sections 5.1, 5.2, 5.3, 5.5, 5.6, 5.7, 5.9).
  - Address impacts using an appropriate time frame (Section 5.1).
  - Assess human health impacts (Section 9.7).
  - Quantify increased air and water contamination (Section 5.2, 5.3).
  - Impact of project on Bitumount Historic Site (Section 7.0).
  - Cumulative effects assessment of water diversions relative to regional water use (Section 5.3).
  - Define "measurable" in relation to impact assessment (Section 5.1).

- **Miscellaneous**

  - Safety issues related to traffic and road conditions of Highway 63 (Section 2.4.8).
  - Solv-Ex environmental policies (Section 2.2.4 and 2.3).
  - Solv-Ex emergency response plans (Section 2.4.1).
  - Transportation route to the plant site (Section 2.1.2).
  - Solv-Ex organizational information (Section 1.1).
  - Legislation that applies to the Experimental Project (Section 1.5).
  - Use an ecological classification for study area (Section 4.6).
  - Include an energy and sulphur balance for project (Section 2.2).
  - List chemicals that are listed in the Canadian Environmental Protection Act Priority Substances List (Section 2.2.2.5).
  - Outline off-site electrical demands (Section 2.1.5).

The on-going public consultation program that Solv-Ex has undertaken has allowed the company to understand the issues that are of concern both locally and provincially. Solv-Ex is committed to continuing consultation with stakeholders during the life of the project and will design monitoring programs in concert with Alberta Environmental Protection and local stakeholders to ensure that all aspects the project meet Alberta Environmental Enhancement and Protection Act regulations.

Future public consultation that will be occurring includes:

- Meetings with The Pembina Institute and Fort McKay First Nations to address their comments on the Draft copies of the Application and Environmental Impact Assessment.

- Discussions with the two trappers that operate Registered Trapping Areas 1650 and 2137 (with Solv-Ex's Local Study Area), regarding compensation for lost trapping opportunities.

- Discussions with Fort McKay to negotiate an Aboriginal Corporate Policy that addresses training and employment opportunities.

- Continued communications to update the Chiefs of Fort Chipewyan and Fort McKay on recent developments associated with the Solv-Ex project.

- Communicating with the general public about activities planned for the summer of 1995 under the Miscellaneous Lease.

- Placing a notice in newspapers informing the public that the EIA has been completed, and distributing copies of the report to interested parties.

3.2 Changes to the Project due to Public Consultation

A detailed review of the issues that were raised by members (written and oral) of the public during consultation and where they were then addressed in the EIA are provided in Section 3.1. Specific environmental issues that were identified through consultation and resulted in alterations to the project are summarized below:

- The energy source for the project was initially designed as a transmission line. However, due to the public's concern about CO_2 greenhouse gas emissions that would be produced elsewhere in the province at the coal-fired electrical generation site, the energy source was changed to diesel fuel that will be trucked to the site.

- The site of the water intake on the Athabasca River was relocated to avoid impacting the Bob Fitzsimmons cabin, which is an historic site.

- Initiating discussions with Aboriginal groups developing corporate policies to maximize Aboriginal employment opportunities.

- Concern about the setback from the Athabasca River, lead to the presentation of two mine configurations, with the second alternative impinging on a smaller stretch of the riverian habitat adjacent to the Athabasca River.

3.3 Participation in the EIA Process by Native Communities

Solv-Ex is committed to including native communities in the EIA process. The company has met with all five regional First Nation Band Chiefs, the Metis Organizations, the trappers on Lease 5 and the surrounding areas, the Athabasca Tribal Corporation and the Northern Alberta Aboriginal Business Association. The list of meetings is summarized in Appendix II.

A workshop was held with the Fort McKay First Nations on March 27, 1995 as part of a program to include them in the EIA process, since they represent the First Nations group that is located closest to the proposed development site. At the workshop, a process was finalized for Fort McKay involvement in the EIA that included:

- Incorporating Fort McKay knowledge of wildlife and traditional use of Lease 5 and of socio-economics for the village of Fort McKay into the EIA by using the Publication prepared by the Fort McKay Environmental Services: *Information Report for Solv-Ex Cumulative Effects Study Area.*

- Inviting members of Fort McKay to participate in the winter track survey, water resources survey and other field programs for the Co-production Experimental Project.

4.0 DESCRIPTION OF BASELINE BIOPHYSICAL RESOURCES

Baseline information on vegetation and soils was defined and mapped using airphoto interpretation. In June 1995, the vegetation, wildlife habitat and soils maps were verified through ground-truthing.

4.1 Air Quality and Noise

4.1.1 *Existing Atmospheric Sources and Emissions*

There are three sources of SO_2 in the Air Resources Study Area, other than Solv-Ex's facility, that have an impact on the regional air quality: Syncrude's main stack, and Suncor's powerhouse and incinerator. The SO_2 emissions from these sources are listed in the following table:

Source	Current SO_2 (t/d)	Future SO_2 (t/d)
Syncrude Main Stack	226	260
Suncor Powerhouse	211	28
Suncor Incinerator	30.5	22

The Syncrude current emissions are based on the 1994 average values and the future emissions are based on the upper limit values specified in the ERCB Decision Report D 94.5 relating to the Syncrude Continued Improvement and Development Project. The Suncor current emissions are based on the 1994 average values and the future emissions are based on the implementation of the Suncor SO_2 Reduction Project (Suncor Inc. 1995). A summary of the stack and emission parameters associated with these three stacks is given in Table 4.1.

4.1.2 *General Climate*

The climate is comprised of many factors which can influence the construction, operation and decommissioning phases of industrial facilities. Extreme climate conditions must be accounted for during the planning stage to optimize future operational efficiencies. Specific parameters discussed in this report include: temperature, frost, precipitation, relative humidity, wind direction and wind speed.

4.1.2.1 Data Sources

Climatology parameters have been monitored in the oil sands regions by various agencies including the following:

Table 4.1 Emission parameters for major existing SO_2 sources, other than the Solv-Ex facility, in the Air Resources Study Area.

Timing		Historical[a]			Future[b]		
		Suncor Powerhouse	Suncor Incinerator	Syncrude Main Stack	Suncor Powerhouse	Suncor Incinerator	Syncrude Main Stack
Stack height	(m)	106.7	106.7	183	137	106.7	183
Stack exit diameter	(m)	5.8	1.8	7.9	7.01	1.8	7.9
Total stack flow rate[c]	(m^3/s)	326.7	19.0	671.4	442.1	17.5	671.4
SO_2 flow rate	(t/d)	210.5	30.5	226.0	28.0	22.0	260
Stack exit temperature	(°C)	256	490	235	63	539	235

(a) Suncor's 1994 average and Syncrude's 1994 average emissions.

(b) Suncor's proposed future emission reduction from Table 4.2.-1 in Suncor Inc. (1995); Syncrude's emissions are the 90-day rolling average licence value.

(c) At 21°C and 101.3 kPa.

- **SandAlta Monitoring Station.** This station was originally established by Gulf Canada as a meteorological and air quality monitoring program at their SandAlta Lease. The station was later maintained by the Research Management Division of Alberta Environment. The data from this site have been summarized by Morrow and Murray (1982) for the period April 1981 to February 1982, Murray (1984) for the period May 1983 to March 1984, Hansen (1985) for the period April 1984 to March 1985 and Hansen (1986) for the period April 1985 to March 1986. The data from April 1984 to March 1986 were available on computer tape and these data provide the basis for most of the SandAlta data analyses presented in this report. The SandAlta monitoring station is located 22 km to the southeast of the proposed Solv-Ex site.

- **Fort McMurray Airport.** This station is operated by the Atmospheric Environment Service (AES). AES is the division of Environment Canada that is responsible for collecting, analyzing, summarizing and archiving climatological parameters at many locations across Canada. Long-term average data are available from a variety of AES publications including Principal Station Data Summaries and Canadian Climate Normals. With respect to the proposed Solv-Ex facility, the Fort McMurray Airport is the nearest AES monitoring station from which long-term monthly data are available. The airport is located in the Athabasca River valley about 60 km south of the Solv-Ex site.

- **The Alberta Oil Sands Environmental Research Program (AOSERP).** This program was jointly operated by Environment Canada and Alberta Environment from 1975 to 1980, and then by Alberta Environment after 1980. Meteorological data were collected from three air quality stations (Birch Mountain, Bitumount and Fort McMurray) and from a 152 m tower located near the Suncor Oil Sands Facility.

Figure 4.1 shows the location of these sites with respect to Fort McMurray, Fort McKay and the proposed Solv-Ex site.

4.1.2.2 Temperature

The climate in the Athabasca Oil Sands regions is typical of that found in a northern continental region and is characterized by warm summers and long cold winters, with short spring and fall transition periods. Figure 4.2 shows the mean and extreme temperatures observed at Fort McMurray Airport (1951 and 1980) and the SandAlta monitoring site (April 1984 to March 1986).

At the Fort McMurray Airport, the mean daily temperature ranges from -21.8°C in January to 16.4°C in July. Mean daily maximum temperatures in excess of 20°C occur in June, July and August. Mean daily minimum temperatures less than -20°C occur in December, January and February. Extreme maximum temperatures in excess of 30°C have occurred in the months from April to September. Extreme minimum temperatures less than -30°C have occurred in the months from November to April.

Similarly, at SandAlta, the mean daily temperature ranges from -27.0°C in February to 15.3°C in July. Mean daily maximum temperatures in excess of 20°C were recorded in the months of June,

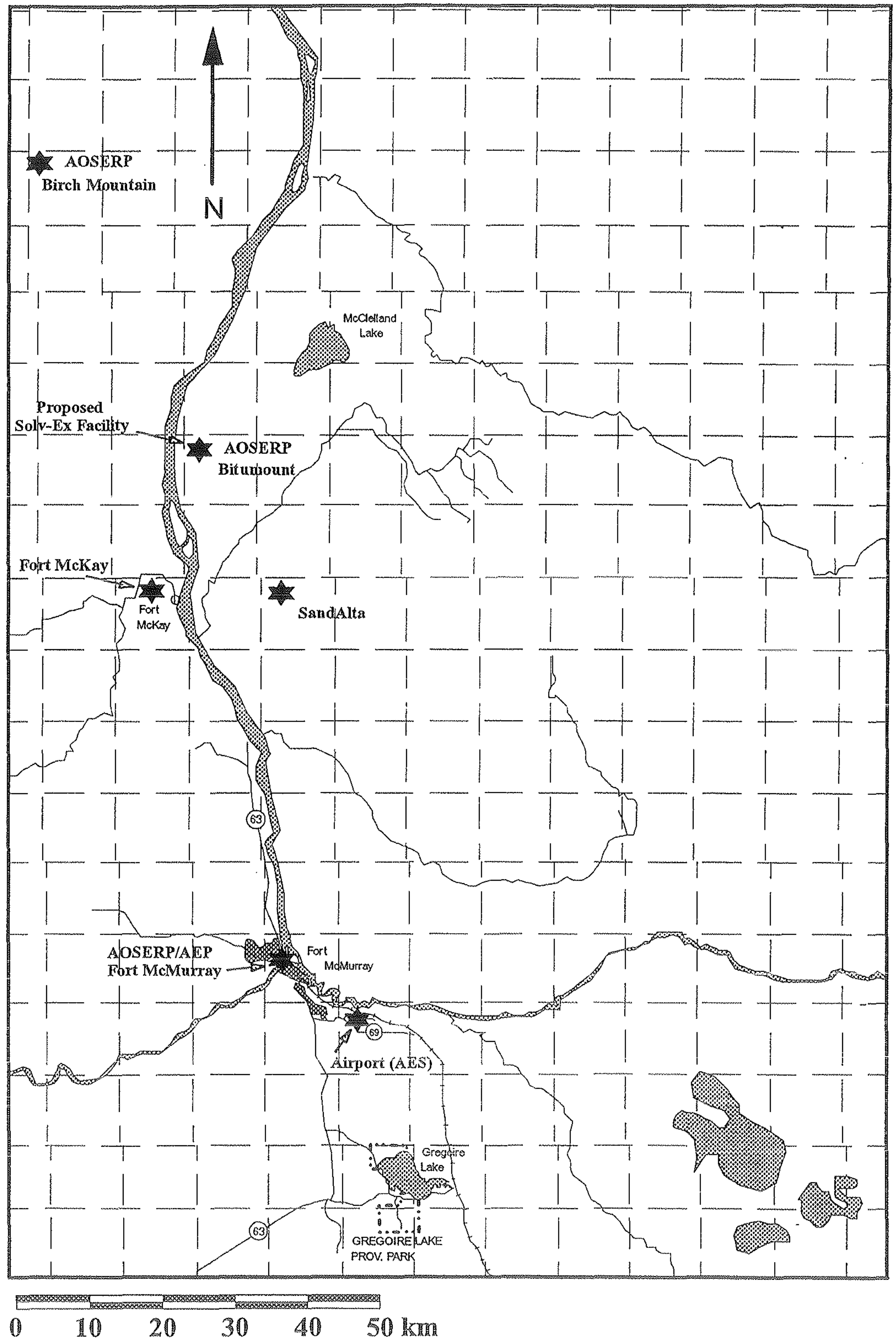


Figure 4.1 Location of climatology stations.

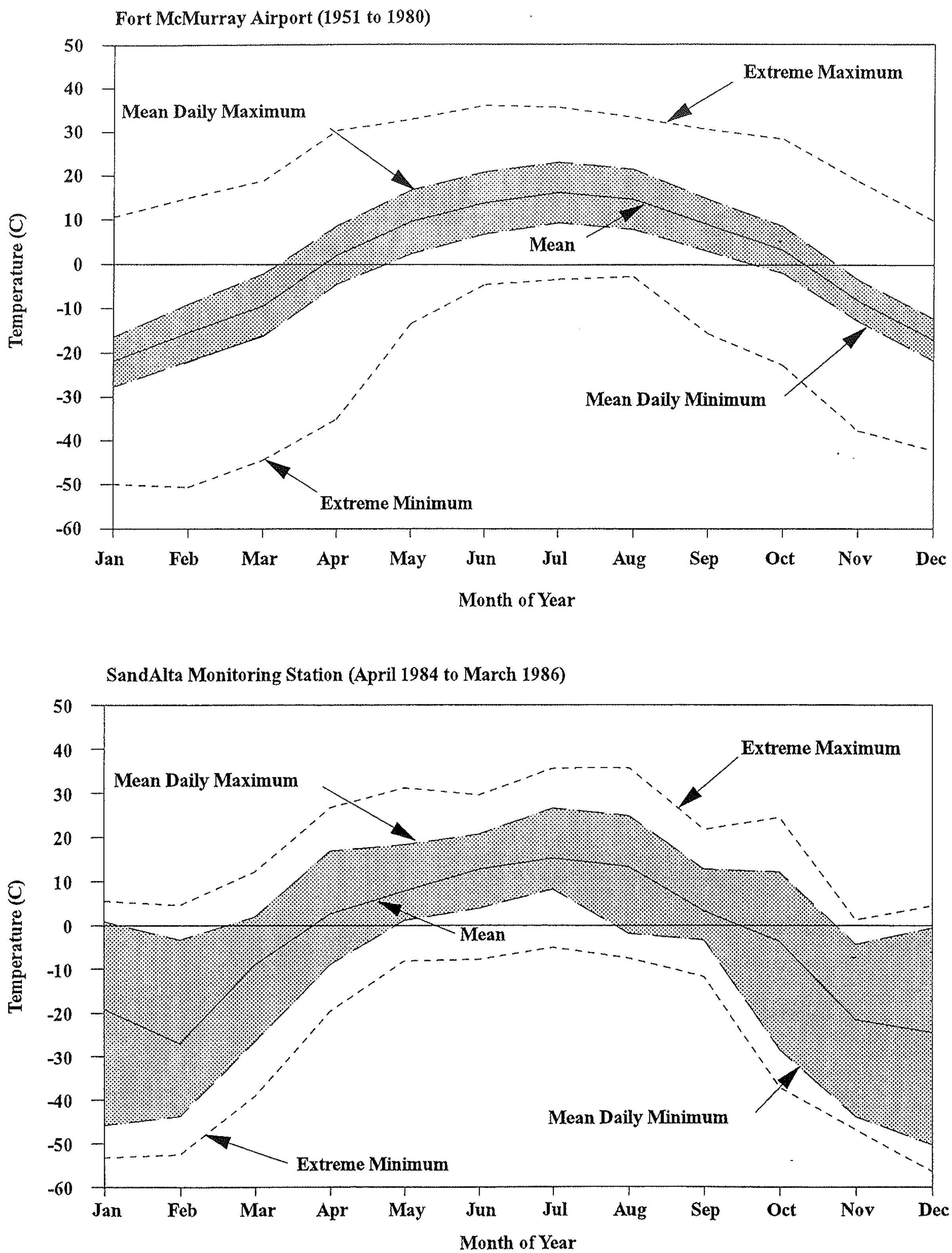


Figure 4.2 Mean and extreme temperatures observed at Fort McMurray Airport (1951 to 1980) and SandAlta monitoring station (April 1984 to March 1986).

July and August. Mean daily minimum temperatures less than -20°C were observed in the months from October to March, inclusive. Mean hourly maximum temperatures in excess of 30°C were observed on at least one occasion in the months from May to August. Mean hourly minimum temperatures less than -30°C have occurred in the months from October to March.

The following table compares the mean seasonal and annual temperatures from the long-term Fort McMurray data with the data collected at the SandAlta monitoring site (same periods as cited earlier):

	Mean Temperature (°C)	
Season	**Fort McMurray**	**SandAlta**
Winter	-18.1	-23.5
Spring	0.9	0.5
Summer	15.1	13.8
Fall	1.4	-7.3
Annual	-0.2	-4.1

As indicated in the table, the temperatures observed at SandAlta (1984 to 1986) were lower than those observed at the Fort McMurray Airport (1951 to 1980).

4.1.2.3 Frost

Table 4.2 shows the probability of frost occurring on or after the indicated date at the Fort McMurray Airport from 1951 to 1980. For example, there is a 66% chance that the last spring frost will occur on or after May 30 and a 25% chance that the first fall frost will occur on or after August 17.

Table 4.3 shows the probability of a frost-free period equal to or less than the indicated number of days at the Fort McMurray Airport from 1951 to 1980. For example, there is a 90% chance that the frost-free period in Fort McMurray will be less than or equal to 115 days in duration.

4.1.2.4 Precipitation

Figure 4.3 shows the mean rainfall (mm), snowfall (cm) and total precipitation (mm) observed at Fort McMurray Airport (1951 to 1980). The maximum mean rainfall of 76.6 mm occurred in August. The maximum mean snowfall of 29.3 cm occurred in December.

Figure 4.4 shows the maximum 24-hour rainfall, snowfall and total precipitation observed at the Fort McMurray Airport (1951 to 1980). The maximum 24-hour rainfall (94.5 mm) and total precipitation occurred in August. The maximum 24-hour snowfall (29.7 cm) occurred in March.

Table 4.2 Probability of frost occurring on or after indicated date at the Fort McMurray Airport (1951 to 1980).

	Earliest	Probability of Frost on or after given Date							Latest
		10%	25%	33%	50%	66%	75%	90%	
Last Spring Frost	May 8	June 30	June 24	June 20	June 10	May 30	May 27	May 18	July 13
First Fall Frost	July 17	Aug. 2	Aug. 17	Aug. 18	Aug. 27	Sep. 3	Sep. 8	Sep. 17	Oct. 3

Table 4.3 Probability of frost-free period equal to or less than indicated period at the Fort McMurray Airport (1951 to 1980).

Shortest	Probability of Frost-Free Period Equal To or Less Than Indicated Number of Days							Longest
	10%	25%	33%	50%	66%	75%	90%	
8	27	60	63	77	86	97	115	128

Source: Atmospheric Environment Service, Environment Canada, 1982. Canadian Climate Normals, Volume 6, Frost, 1951-1980.

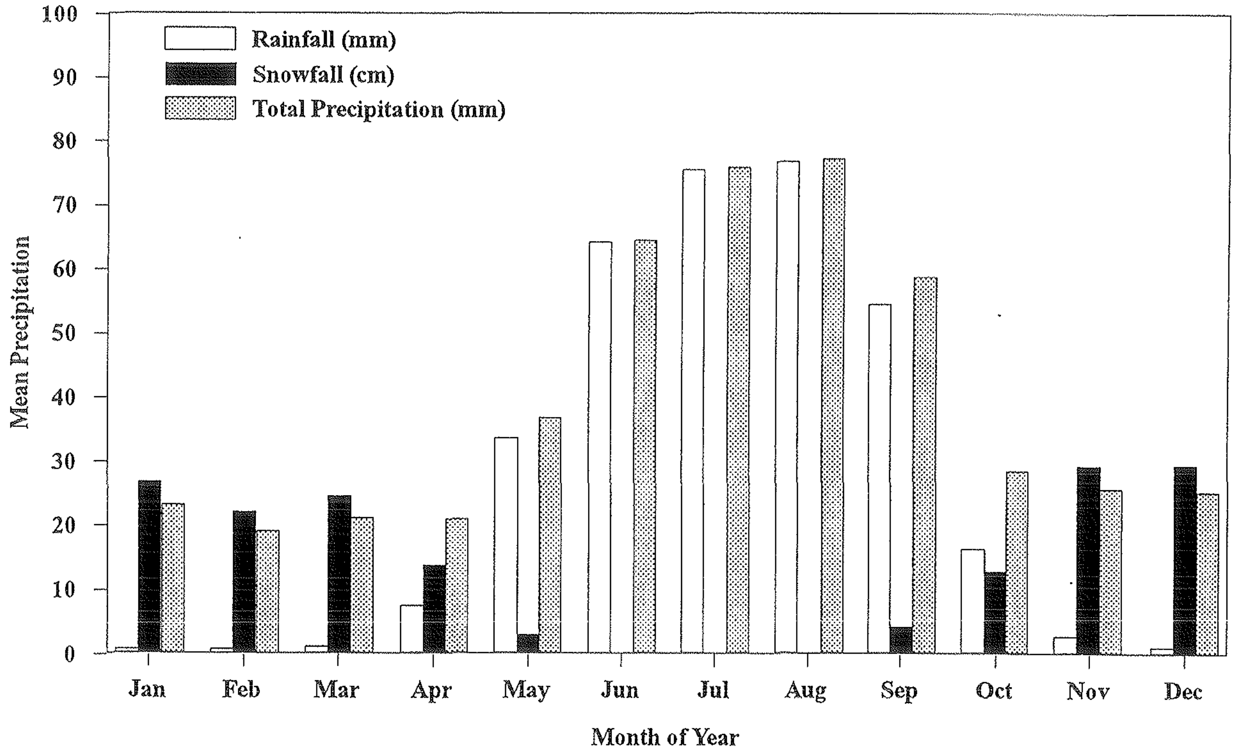


Figure 4.3 Mean rainfall (mm), snowfall (cm), and total precipitation (mm) observed at Fort McMurray Airport (1951 to 1980).

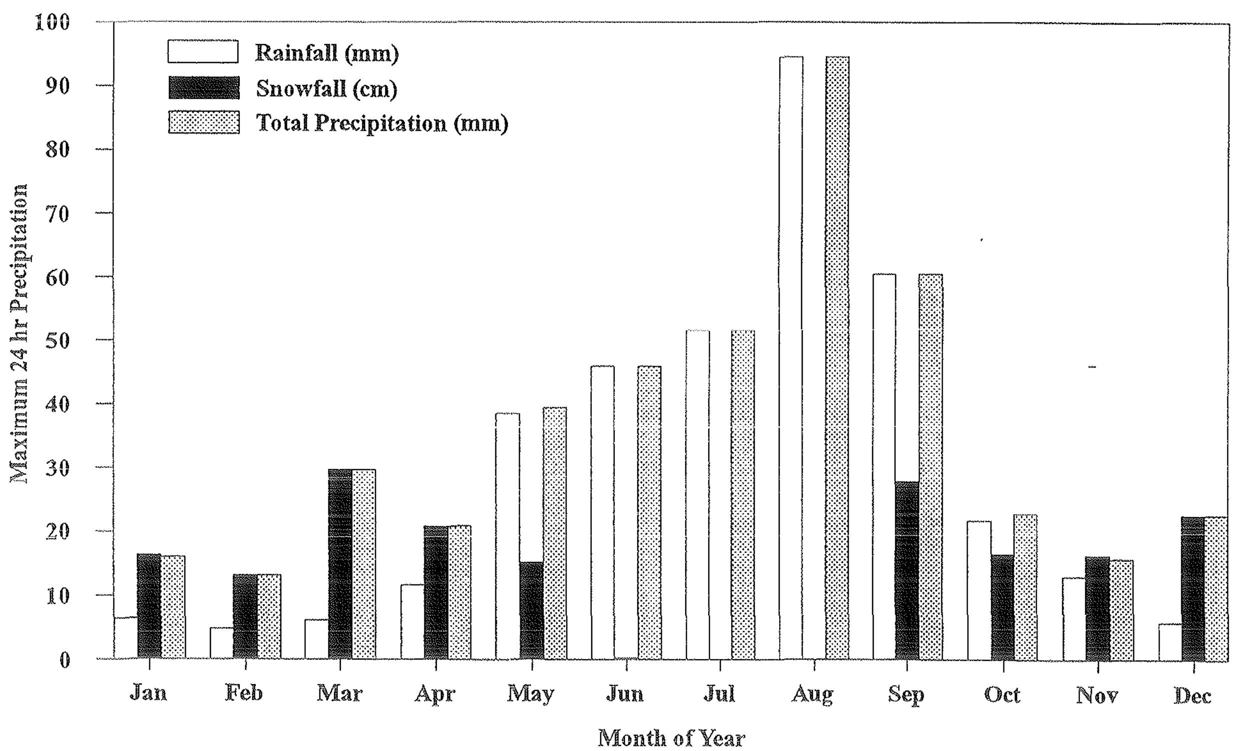


Figure 4.4 Maximum 24-hour rainfall (mm), snowfall (cm), and total precipitation (mm) observed at Fort McMurray Airport (1951 to 1980).

Figure 4.5 indicates the mean number of days with measurable precipitation at the Fort McMurray Airport (1951 to 1980). Normally, there are 8 to 14 days per month when precipitation was observed. On average, Fort McMurray has 140 days per year with measurable precipitation.

Table 4.4 presents the frequency of precipitation as a function of season and the mean seasonal precipitation intensity based on Fort McMurray Airport observations. The mean seasonal and annual total precipitation (mm) are also shown. Precipitation occurs most frequently (32.7% of the time) during the winter, with the greatest intensity (0.9 mm/h) during the summer months.

4.1.2.5 Relative Humidity

Figure 4.6 shows the mean monthly relative humidity observed at the Fort McMurray Airport (1951 to 1980). Humidity readings are shown for four times during the day (i.e., 00:00, 06:00, 12:00 and 18:00 Mountain Standard Time) and as a mean representing all hours of the day. Generally, the lowest relative humidity values are associated with daytime hours, when the air is warm and conversely, the highest values are associated with nighttime hours, when the air is cooler and has less capacity to hold water vapour. The highest mean daily relative humidity of 80% occurs in December. The lowest mean daily value of 64% occurs in June.

Figure 4.6 also shows data collected at the SandAlta site from April 1981 to February 1982. No data are available for the month of March. During the winter months, when the air is cooler and has less capacity to hold moisture, the relative humidity is highest. Due to various air masses which influence the area in the summer, the range of relative humidity is greater than during the winter months. For instance, in June, the relative humidity can range from 6 to 99% with a mean of 67%, while during December, the relative humidity ranges from 61 to 97% with a mean of 85%.

4.1.2.6 Wind Direction

Longley and Janz (1978) compared wind data from various locations in the oil sands area with those from Fort McMurray Airport and concluded the following:

- Data collected at Fort McMurray Airport show a definite east-west predominance due to the influence of the Clearwater River Valley.

- Stations north of Fort McMurray along the Athabasca River show a tendency for north-south winds.

- Stations removed from the river valleys, such as Birch Mountain show an increased frequency of westerly winds.

Longley and Janz concluded from their analysis that wind data for the AOSERP study area cannot be transposed from one locality to another. Wind data are valid only for the area in the immediate vicinity of the wind monitoring site. This conclusion has been supported by subsequent studies (Lehey and Hansen 1982).

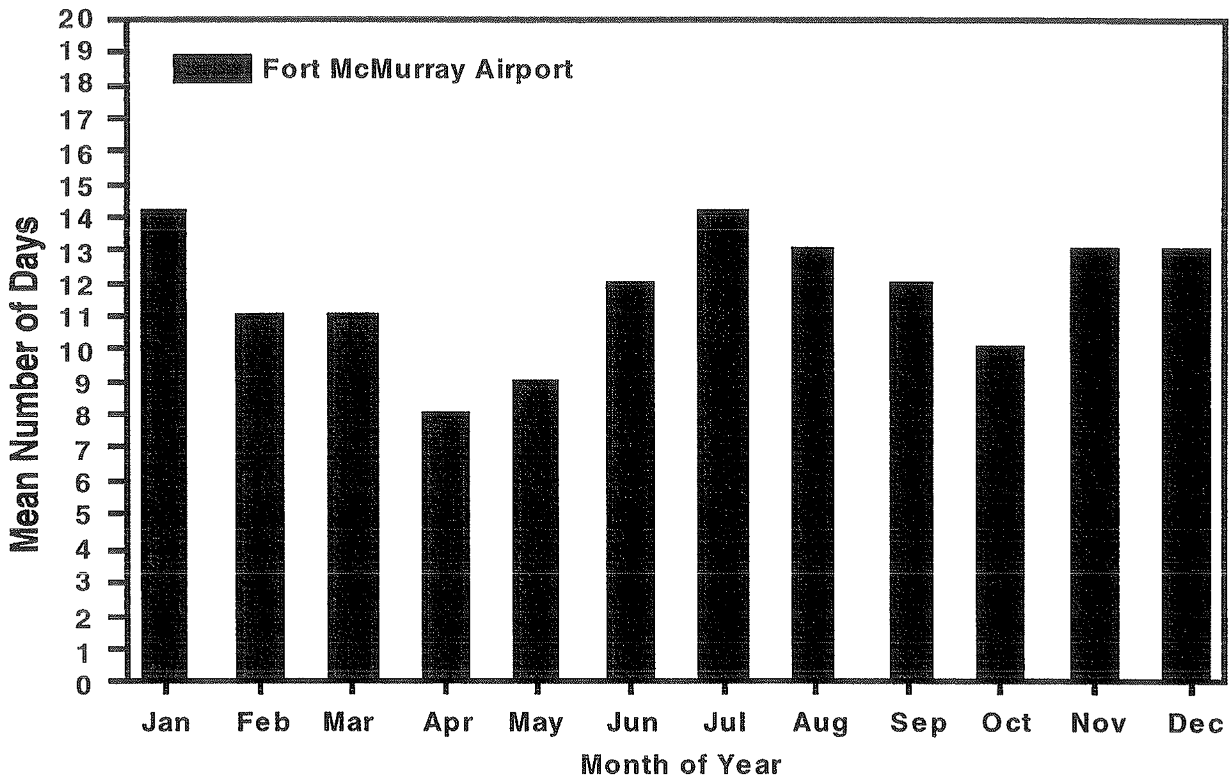


Figure 4.5 Mean number of days with measurable precipitation at the Fort McMurray Airport (1951 to 1980).

Table 4.4 Season and annual frequency of total precipitation (%) and precipitation intensity (mm/h) observed at the Fort McMurray Airport (1951 to 1980).

Season	Total Precipitation (mm)	Frequency (%)	Intensity (mm/h)
Winter	66.5	32.7	0.094
Spring	77.5	14.4	0.282
Summer	216.1	10.9	0.901
Fall	111.8	18.8	0.319
Annual	471.9	19.2	0.399

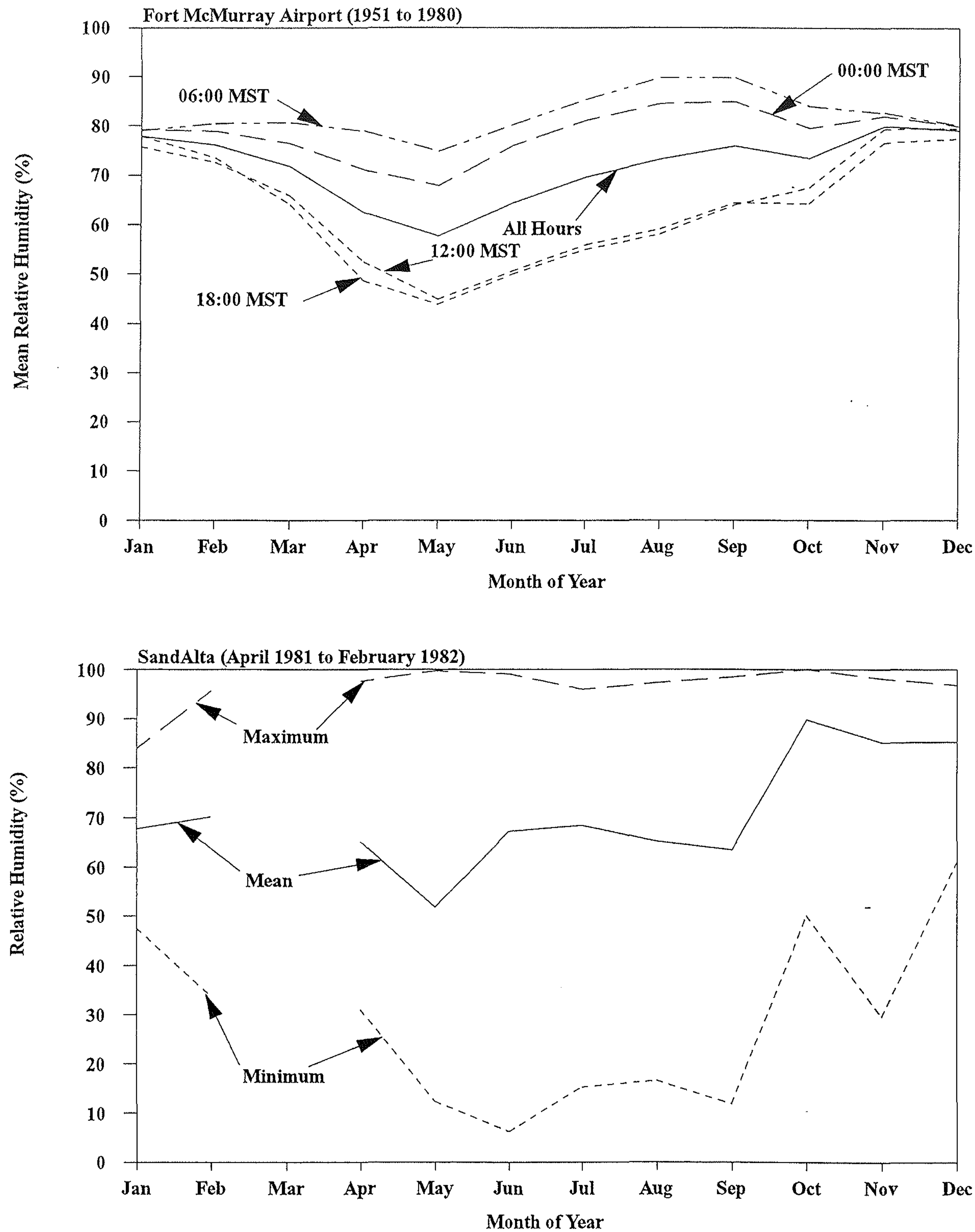


Figure 4.6 Mean relative humidity (%) observed at Fort McMurray Airport and SandAlta monitoring station.

Wind direction data can be plotted graphically using a "wind rose" diagram. Each wind rose consists of 16 rays extending from an inner circle towards the outer edge of the diagram. The total length of each ray indicates the percent frequency of wind from each of the 16 wind directions represented. Each ray is composed of shorter bars representing various wind speed categories.

Figure 4.7 shows the annual wind roses for the Fort McMurray Airport (1975 to 1988), the AOSERP Birch Mountain station (1976 to 1979) and the SandAlta monitoring site (11 m, April 1984 to March 1986). The wind rose for Fort McMurray indicates east-west predominance due to the Clearwater River Valley orientation. The Birch Mountain location shows a greater frequency of northwesterly winds and is likely representative of higher elevation winds. The annual wind rose for SandAlta is somewhat more evenly distributed, but indicates a slight northwest-southeast tendency.

4.1.2.7 Wind Speed

Longley and Janz (1978) concluded that the wind speeds in the area are small when compared to those in southern Alberta. Large wind speed values can occur, but they are rare and seldom persist for extended periods of time. Figure 4.8 shows the annual wind speed frequency distributions for Fort McMurray Airport (1975 to 1988), the AOSERP Birch Mountain station (1976 to 1979) and the SandAlta monitoring site (April 1984 to March 1986). No seasonal data are available for the Birch Mountain site.

For Fort McMurray, wind speeds occur most frequently (more than 30% of the time) between 6 and 11 km/h on an annual basis, while wind speeds in excess of 19 km/h occur between 9 and 11% of the time. At Birch Mountain, the highest percentage of winds on an annual basis occur between 12 and 19 km/h (more than 40% of the time), with wind speeds in excess of 19 km/h occurring about 30% of the time. The SandAlta data indicate that the highest percentage of winds on an annual basis occur between 1 and 5 km/h (approximately 38% of the time), while wind speeds in excess of 19 km/h occur less than 1% of the time.

The following table compares the mean seasonal and annual wind speeds for the Fort McMurray Airport and SandAlta monitoring locations (anemometer height in brackets):

Season	**Mean Wind Speed (km/h)**	
	Fort McMurray (10 m)	**SandAlta (11 m)**
Winter	8.6	4.3
Spring	10.8	5.8
Summer	9.4	5.8
Fall	10.9	4.7
Annual	9.7	5.0

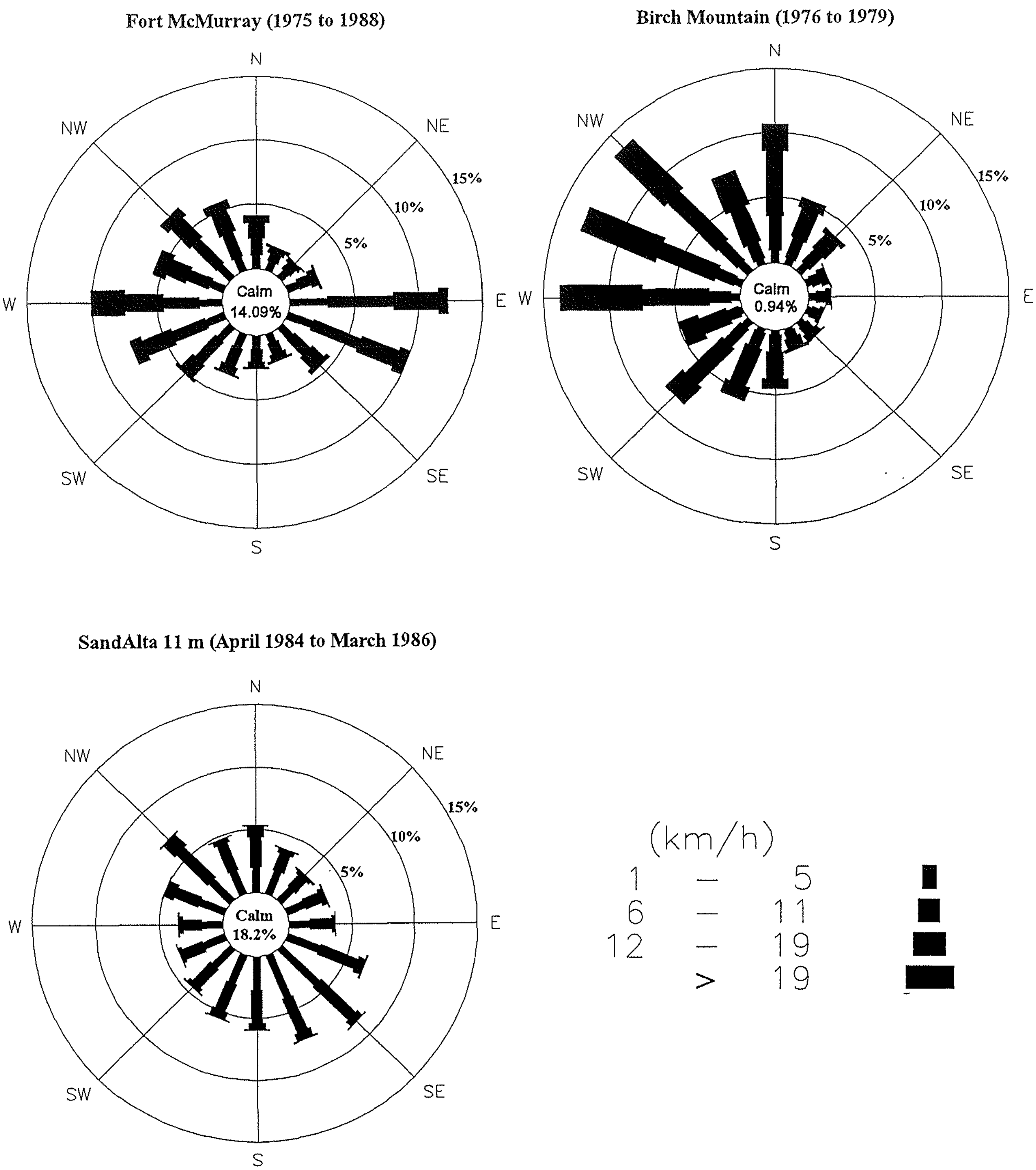


Figure 4.7 Annual wind direction and wind speed frequency distributions for Fort McMurray Airport, Birch Mountain and SandAlta montioring sites (periods indicated).

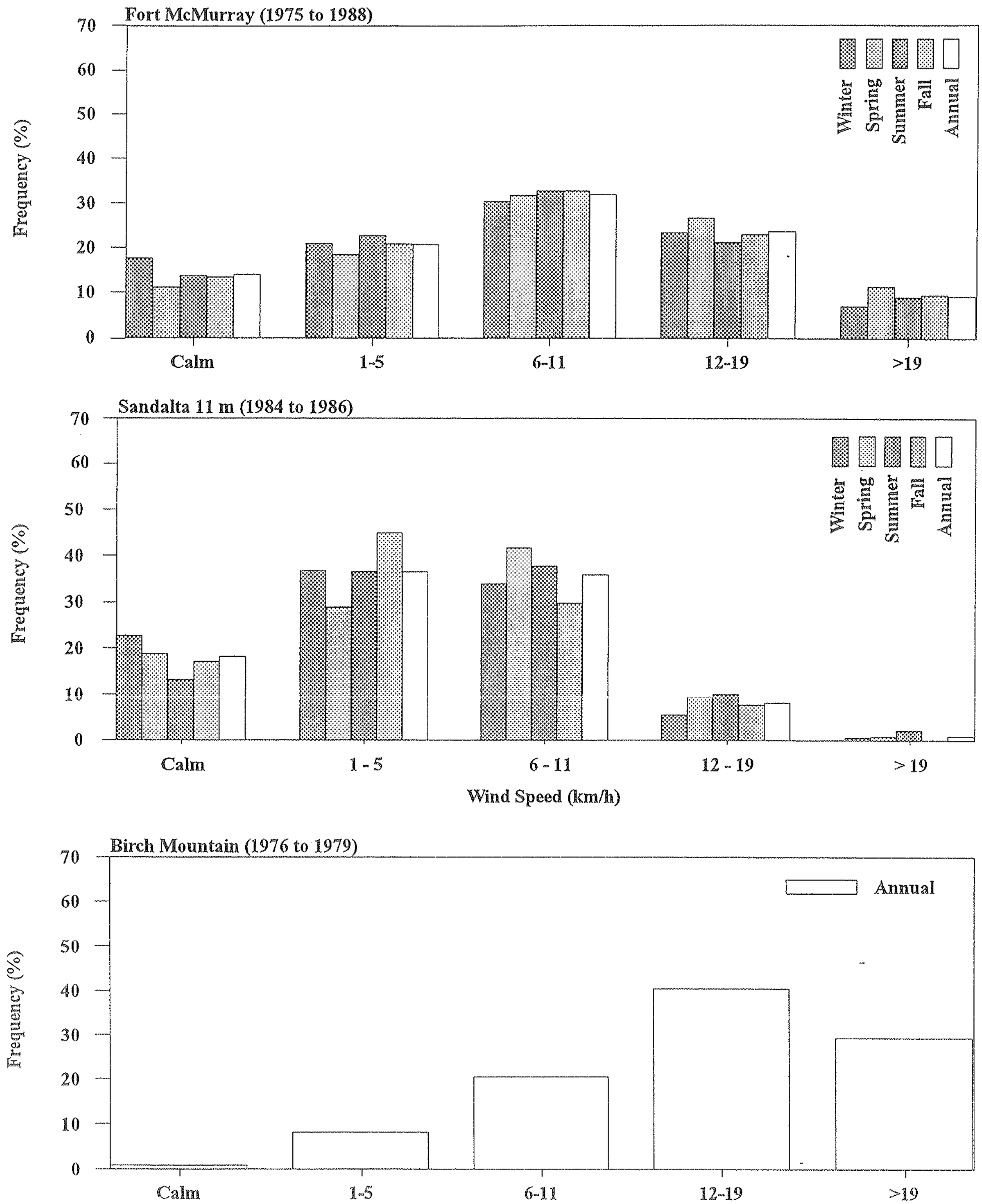


Figure 4.8 Percent frequency distributions of wind speed at selected monitoring sites.

As previously indicated, the wind speeds at Fort McMurray tend to be greater than those observed at SandAlta. The airport wind sensor is located in an open grassy area near the runway, while the SandAlta site is adjacent to a forest canopy which has the effect of slowing the wind.

4.1.3 *Dispersion Climatology*

Meteorology controls the transport and dispersion of gaseous and particulate emissions that have been released to the atmosphere. Specific meteorological parameters of relevance include:

- Wind direction
- Wind speed
- Temperature stratification
- Mixing height
- Atmospheric stability class

These parameters are used by the models to simulate the behaviour of the atmosphere and assess changes to ambient air quality. Since not all of these values are measured routinely by the Atmospheric Environment Service (AES), these data are frequently collected from on-site meteorological measurements. In some cases, certain dispersion parameters have to be estimated from indirect observations and algorithms based on our understanding of atmospheric boundary layer behaviour.

The meteorological observations collected at the proposed SandAlta lease site from April 1984 to March 1986 were used to determine the dispersion meteorology for the area. SandAlta data was selected for use in dispersion modelling over the AOSERP Bitumount tower site for several reasons:

- The Bitumount tower is not in the valley, but is located on the Fort Hills above the valley. Although this site is at the same elevation as the top of the main stack, the atmospheric behaviour may not reflect the conditions nearer the plant site as well as SandAlta because of the valley effects.

- The SandAlta site is at a similar elevation to the proposed plant site which would better represent the meteorological conditions expected at Solv-Ex.

- Most importantly, the meteorological information from Bitumount is insufficient to conduct dispersion analyses due to the lack of time series data and concurrent indicators of turbulence, solar radiation, etc., essential to determining stability classes.

4.1.3.1 Wind Parameters

The seasonal wind direction and wind speed frequencies are given in Figure 4.9 as observed at the SandAlta monitoring site's 11 m tower. The trend toward northwesterly and southeasterly winds is more dominant in the winter and fall, with a slight tendency for more southerly winds occurring in summer.

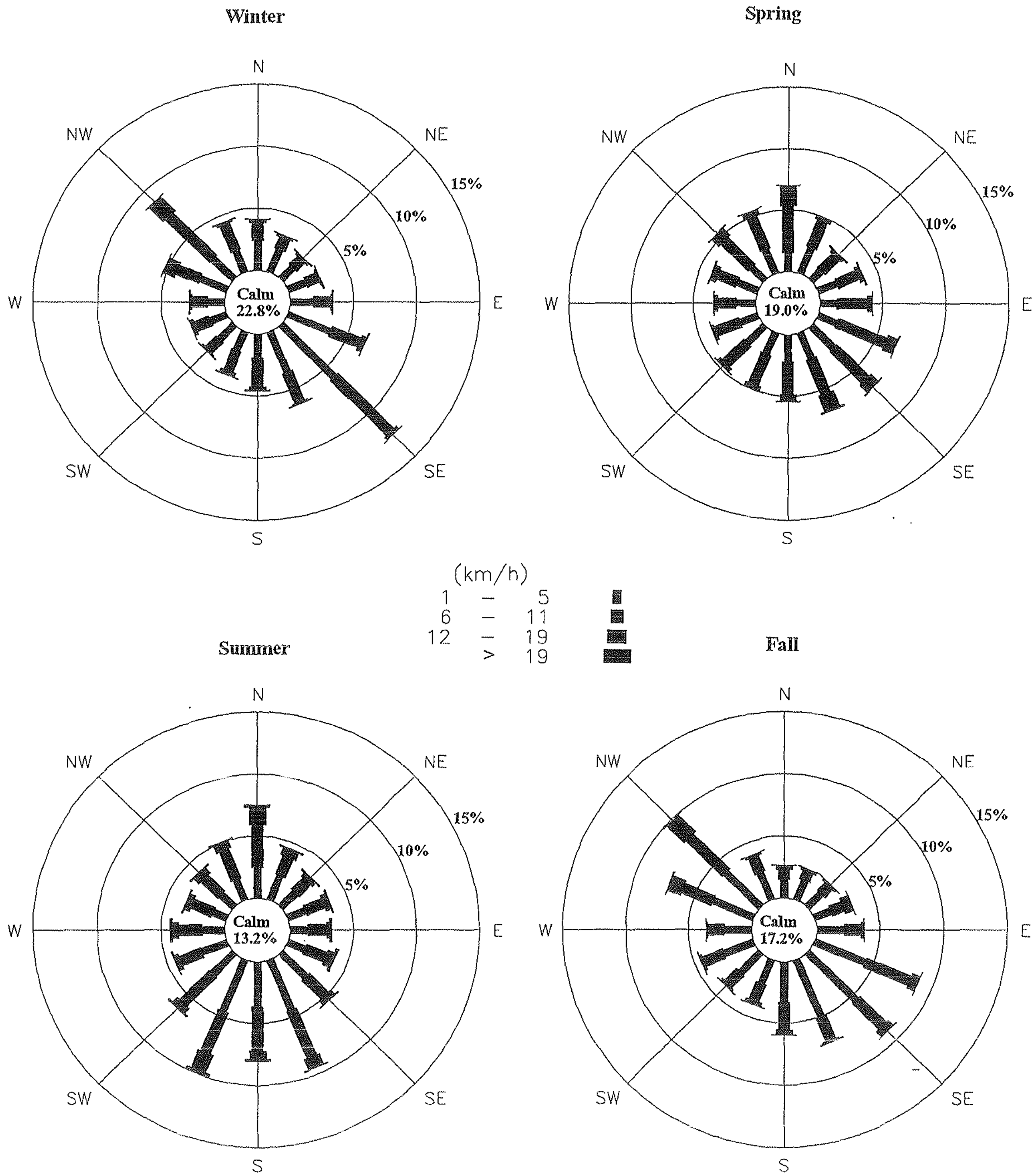


Figure 4.9 Seasonal wind direction and wind speed frequency distributions for data collected from the 11 m level at the SandAlta monitoring site (April 1984 to March 1986).

Wind speeds in the region tend to be relatively low but increase with height above the surface due to the interaction between the surface and upper-level airflows. In forested areas, surface winds are slower relative to open areas due to the increased frictional influence of the trees. The frequency distributions of wind speeds observed at the two tower heights at SandAlta are shown in Figure 4.10. It illustrates the pattern of greater wind speeds with increasing height above the ground.

The 99th percentile wind speed is often used to ensure that stack tip downwash is minimized (Alberta Environment, 1988); i.e., downwash may occur less than 1% of the time. The 99th percentile winds observed (at the heights indicated in brackets) in the area are:

- SandAlta (11 m) 19 km/h (5.3 m/s)
- SandAlta (46 m) 27 km/h (7.5 m/s)

Observations then suggest that a stack 46 m in height should emit gas with a velocity no less than 7.5 m/s to avoid stack tip downwash. The proposed Solv-Ex stack exit velocities are in the 12 to 20 m/s range and, therefore, downwash effects should be infrequent.

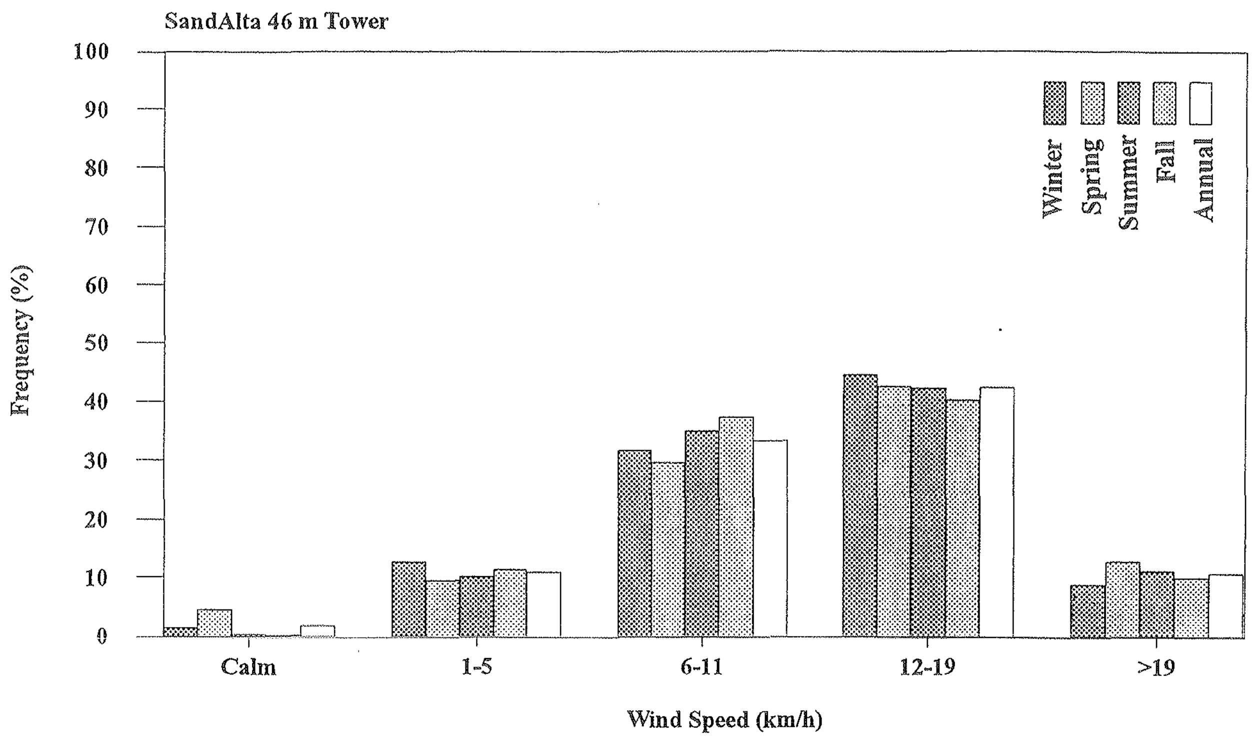
4.1.3.2 Temperature Stratification

The thermal stability of the atmosphere is determined by the vertical temperature gradient. A well-mixed atmosphere is characterized by a temperature profile that cools 1 C° for every 100 m in height increase. The temperature gradient ($\Delta T/\Delta Z$) is therefore -1 C°/100 m. This is referred to as the dry adiabatic lapse rate.

During daylight hours when solar radiation heats the earth, the air in contact with the ground becomes warmer than the air aloft. Under these conditions, the temperature gradient is more negative than the adiabatic lapse rate (e.g., -2 C°/100 m). As the warm, less dense air rises, an **unstable** atmospheric condition is created.

During the night, the earth cools due to radiational heat losses. Air in contact with the ground becomes cooler and more dense than the air aloft. The temperature gradient is less negative than the adiabatic lapse rate and may become positive (increase with height) (e.g., +1 C°/100 m). In these cases, a **stable** atmospheric condition is created.

Due to difficulties in measuring plume level temperature gradients, many dispersion models employ representative default values for convenience. For the ADEPT2 model, the default gradients of 0.02 C°/m for slightly stable conditions (stability class E) and 0.04 C°/m for stable conditions (stability class F) were used. For the same meteorological conditions, the other models (ISCST2, ISCON5, SCREEN2 and RTDM3.2) used their respective default gradients of 0.03 and 0.035 C°/m. These gradients refer to plume level temperature profiles and not to near surface-level values.



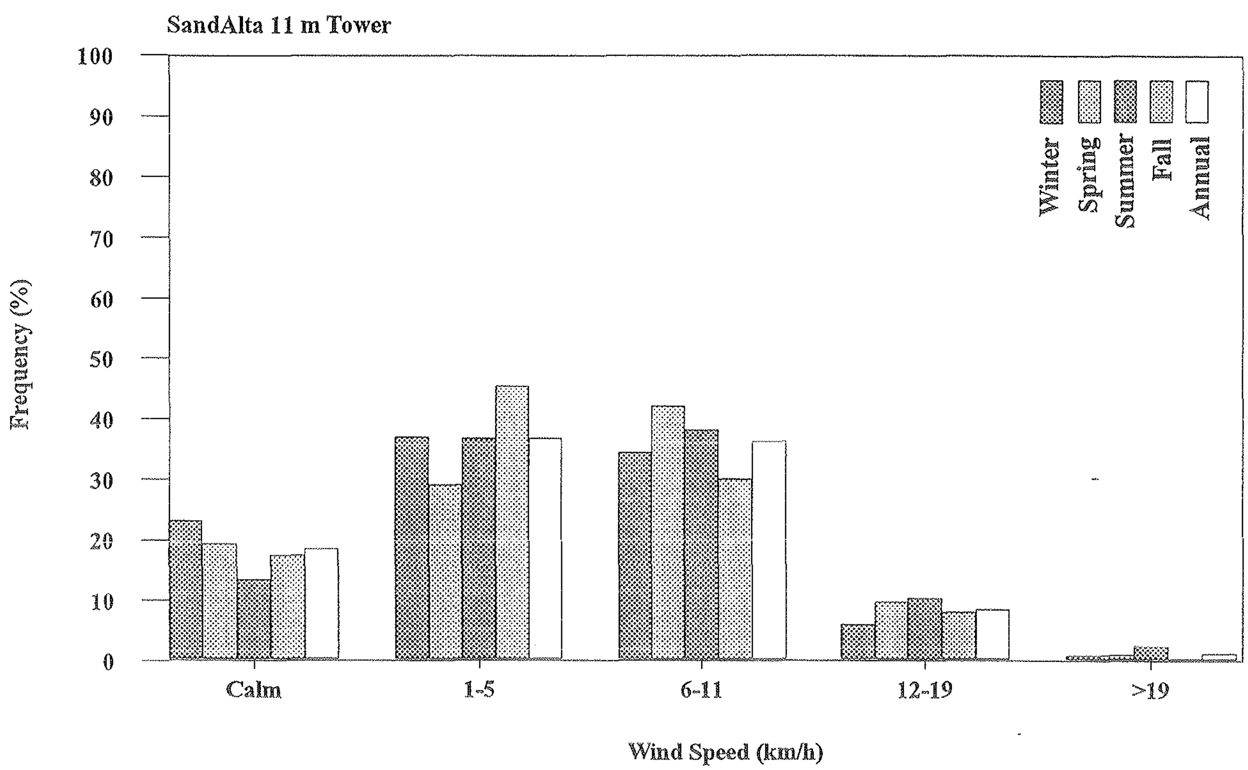


Figure 4.10 Wind speed frequency distributions for data collected from the 11 m and 46 m levels at the SandAlta monitoring site (April 1984 to March 1986).

4.1.3.3 Turbulence

A temperature increase with height is referred to as an inversion. The base of the temperature inversion may be ground-based or elevated. In the case of the latter, a two-layered atmosphere is created. The lower layer tends to be well-mixed and is characterized by neutral or unstable conditions. The depth of this lower layer is referred to as the mixing height. The upper layer tends to be characterized by stable conditions. The vertical transfer of mass between these two layers is minimal.

During the night, the mixing layer is determined by the mechanical interaction of the wind with surface features. Maximum mixing layer depths tend to be a few hundred metres. The depth of the mechanical mixed layer can be estimated from the relationship:

$$Z_m = 320\,U$$

where U is the wind speed at 10 m (m/s) and is centre-averaged over a three-hour period. The above relationship from the SCREEN2 model assumes a surface roughness length of 30 cm, a von Karman constant of 0.3 and a Coriolis parameter of $9.374 \times 10^{-5}\ s^{-1}$.

After sunrise, the solar heating usually determines the depth of the mixing layer. Typical depths increase from the mechanical mixing height at sunrise to heights of up to a few thousand metres by mid-afternoon. Mean maximum afternoon mixing depths for the oil sands area were obtained from an evaluation of the AOSERP minisonde temperature profiles. Table 4.5 shows the seasonal and monthly mean maximum afternoon mixing heights in the oil sands area. The seasonal values are based on the Davison *et al.* (1981) seasonal summary while the monthly values were interpolated. The largest values are associated with the months with the strongest solar radiation (May, June and July) and the smallest values with the months with the weakest solar radiation (December, January and February). The AOSERP values are based on 2222 minisonde releases conducted in 1975, 1976, 1977 and 1979. The minisonde data were not uniformly distributed over all months of the year; the observations are biased to the months of February, March, July and August.

For time series modelling, hourly values of the mixing heights are required. The following describes the approach that was used to generate these values from the SandAlta data.

- Mechanical mixing height values were estimated from $Z_m = 320$ U where U is the three-hour, centre-averaged 11 m level wind speed (m/s). The minimum wind speed was taken as 1 m/s for the above relationship.

- The convective mixing height values were assumed to grow linearly from sunrise (radiation ≥ 0) to monthly climatological afternoon maximum values. The time of the maximum was taken as 14:00, 15:00, 14:00 and 13:00 hours for winter, spring, summer and fall, respectively. The different times reflect the diurnal variation exhibited in the AOSERP data (Davison *et al.* 1981).

Table 4.5 Mean maximum afternoon mixing heights (m) on a monthly and seasonal basis.

Seasonal:

Season	Median AOSERP Minisonde
Winter	270
Spring	1000
Summer	1000
Fall	800
Annual	870

Monthly:

Month	Median Interpolated
January	270
February	550
March	810
April	1000
May	1080
June	1060
July	1000
August	955
September	900
October	800
November	650
December	465
Annual	870

- From the time of the maximum to sunset, the mixing height was assumed to be constant.

Figure 4.11 shows the median diurnal and seasonal mixing height variations based on the SandAlta meteorological data set. The largest mixing heights occur in the spring and summer, while the smallest values occur during the winter.

Atmospheric Stability

Atmospheric turbulence determines the dilution of a plume as it is transported by the wind. The turbulence may be generated by either thermal or mechanical mechanisms. Surface heating and cooling by radiation contribute to the generation of thermal turbulence, while high wind speeds contribute to the generation of mechanical turbulence.

Meteorologists frequently use the Pasquill-Gifford (PG) stability classification scheme when classifying the amount of turbulence present in the atmosphere. These classes range from **Unstable** (Stability Classes A, B and C) through **Neutral** (Stability Class D) to **Stable** (Stability Classes E and F). Unstable conditions are primarily associated with daytime heating which results in enhanced turbulence levels. Stable conditions are associated primarily with nighttime cooling which results in suppressed turbulence levels. Neutral conditions are primarily associated with high wind speeds.

A number of turbulence typing schemes have been developed to relate meteorological observations to the Pasquill-Gifford Stability Classes A through F.

- The Turner (1964) STAR program was applied to the Fort McMurray Airport observations for the periods 1975 to 1984. This scheme which uses routine airport observations of wind speed and cloud cover.

- The Modified Bowen *et al.* (1983) scheme was used to estimate the PG stability class from the SandAlta data. This method is based on wind speed and solar radiation during the day and wind speed and temperature gradient during the night.

Figure 4.12 shows the comparison of Fort McMurray and SandAlta stability class frequency distributions according to season. On average, stable conditions occur more frequently in the winter and unstable conditions are more frequent in the summer. The comparisons indicate the following frequencies:

Location	Unstable (%)	Neutral (%)	Stable (%)
Fort McMurray	13	48	39
SandAlta	34	19	47

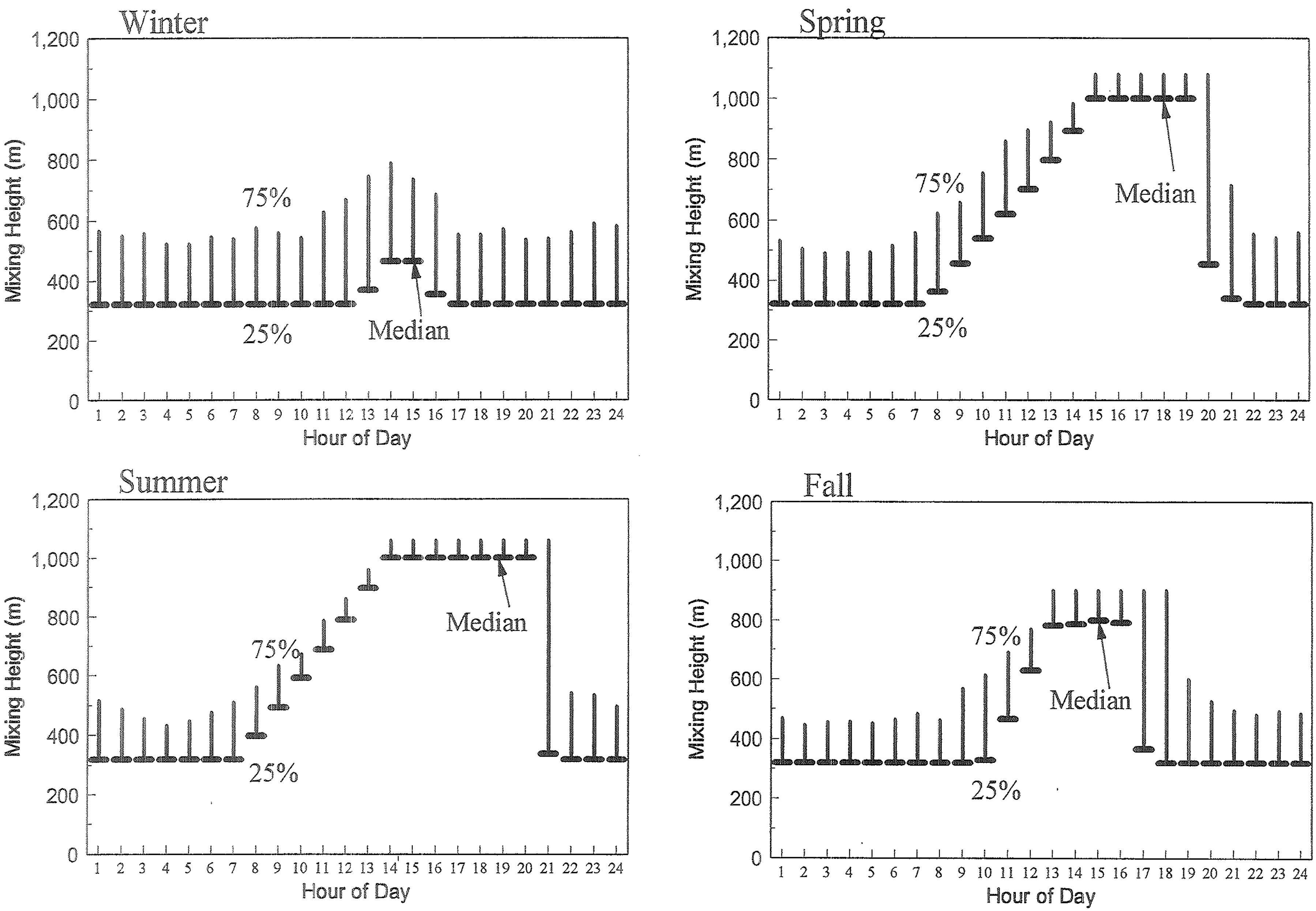
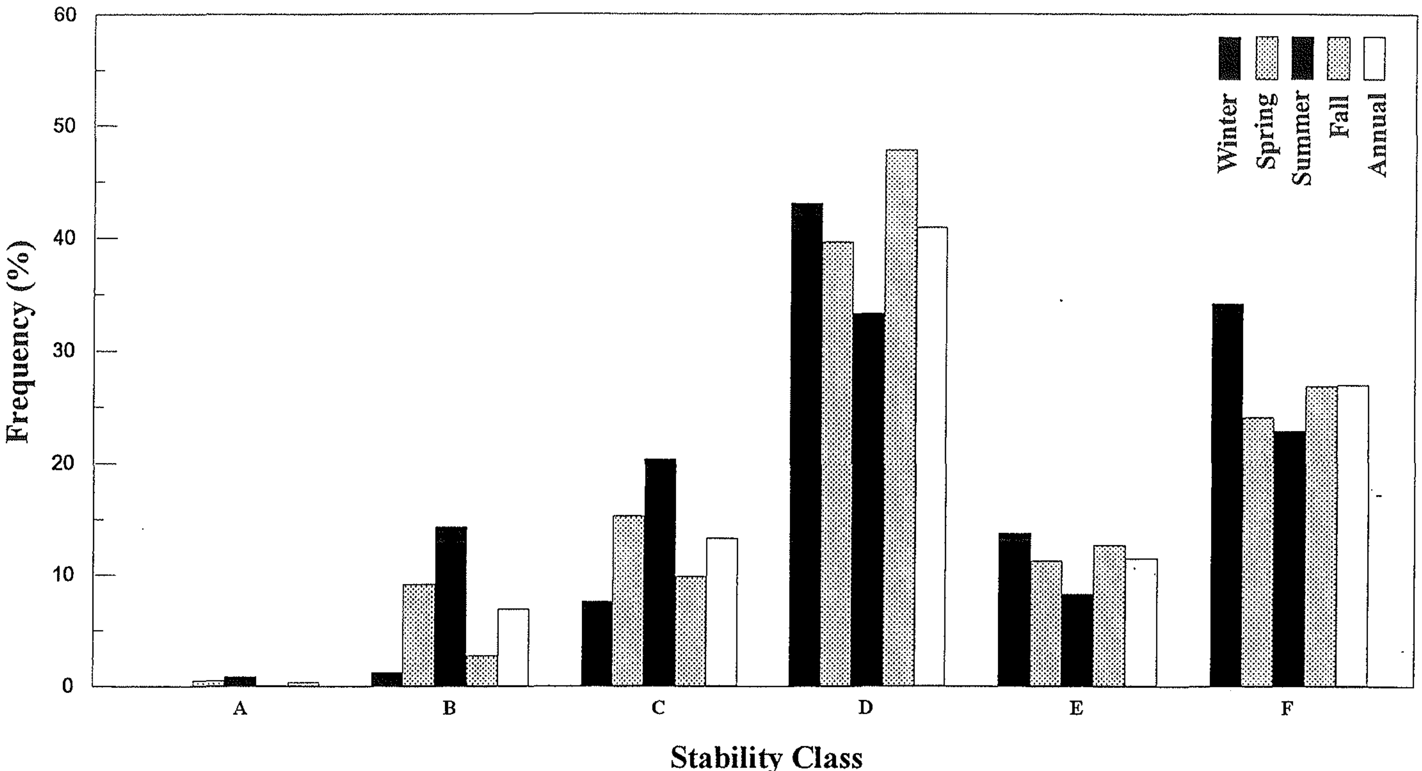


Figure 4.11 Diurnal variation of mixing height based on the SandAlta data.

Fort McMurray Airport



SandAlta (11 m)

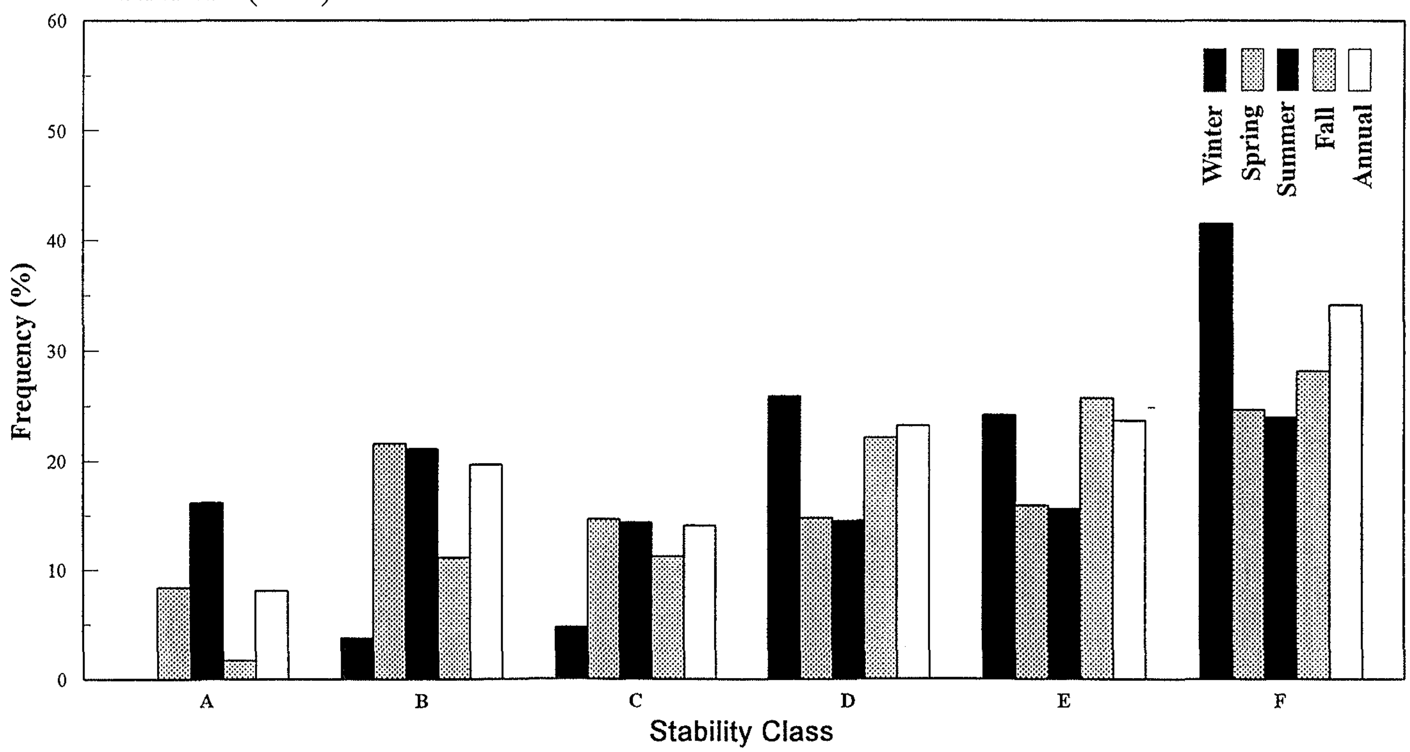


Figure 4.12 Seasonal stability class frequency distributions for data collected from the 11 m level at the SandAlta monitoring site (April 1984 to March 1986) and the Fort McMurray Airport (1975 to 1984).

The differences between the stability class estimates indicate some of the inherent uncertainties in describing the dispersion climatology of the area from the available data. The method applied to the SandAlta observations indicates more unstable and stable conditions at the expense of neutral conditions when compared to the STAR approach applied to Fort McMurray airport. There have been suggestions that the STAR approach overestimates neutral conditions (Mitchell 1982, Sedifian 1980).

Figure 4.13 shows the hourly variation of the stability class for the SandAlta data set for each season. The figure indicates the expected diurnal variation of unstable conditions (PG classes A, B and C) during the day and stable conditions (PG classes E and F) during the night. Similarly the expected seasonal trends of more stable conditions during the winter and more unstable conditions during the summer are also shown.

4.1.4 *Observed Air Quality*

Air quality is defined by the presence or absence of contaminants in the air. Contaminants are defined as trace constituents that are not permanent atmospheric components with the connotation of being derived from industrial activity. Air quality can be related to ambient concentrations in the air or in the precipitation.

The operation of the proposed Solv-Ex facility will result in contaminant emissions that will be combined with those from existing sources in the area. Because of this contribution, the background air quality, that is the quality of the air prior to Solv-Ex development in the area, needs to be defined.

The background air quality and the air quality changes associated with Solv-Ex's operation can then be combined to determine the overall air quality in the area. This air quality can then be compared with the appropriate air quality objectives and guidelines.

4.1.4.1 Air Quality Objectives

In humans, contaminants can be directly inhaled and in the extreme, produce adverse health consequences. Furthermore, the contaminants can also have direct and indirect effects on animals, vegetation, soil, water and visibility. It is for this reason that environmental regulatory agencies have established concentration limits in the atmosphere that are typically based on the lowest observed level of effect on receptors.

Table 4.6 presents the Alberta Provincial and Canadian Federal Government air quality objectives for regulated contaminants. The contaminants include: sulphur dioxide (SO_2), hydrogen sulphide (H_2S), nitrogen dioxide (NO_2), carbon monoxide (CO), oxidants expressed as ozone (O_3) and total suspended particulates (TSP). These objectives refer to averaging periods ranging from one hour

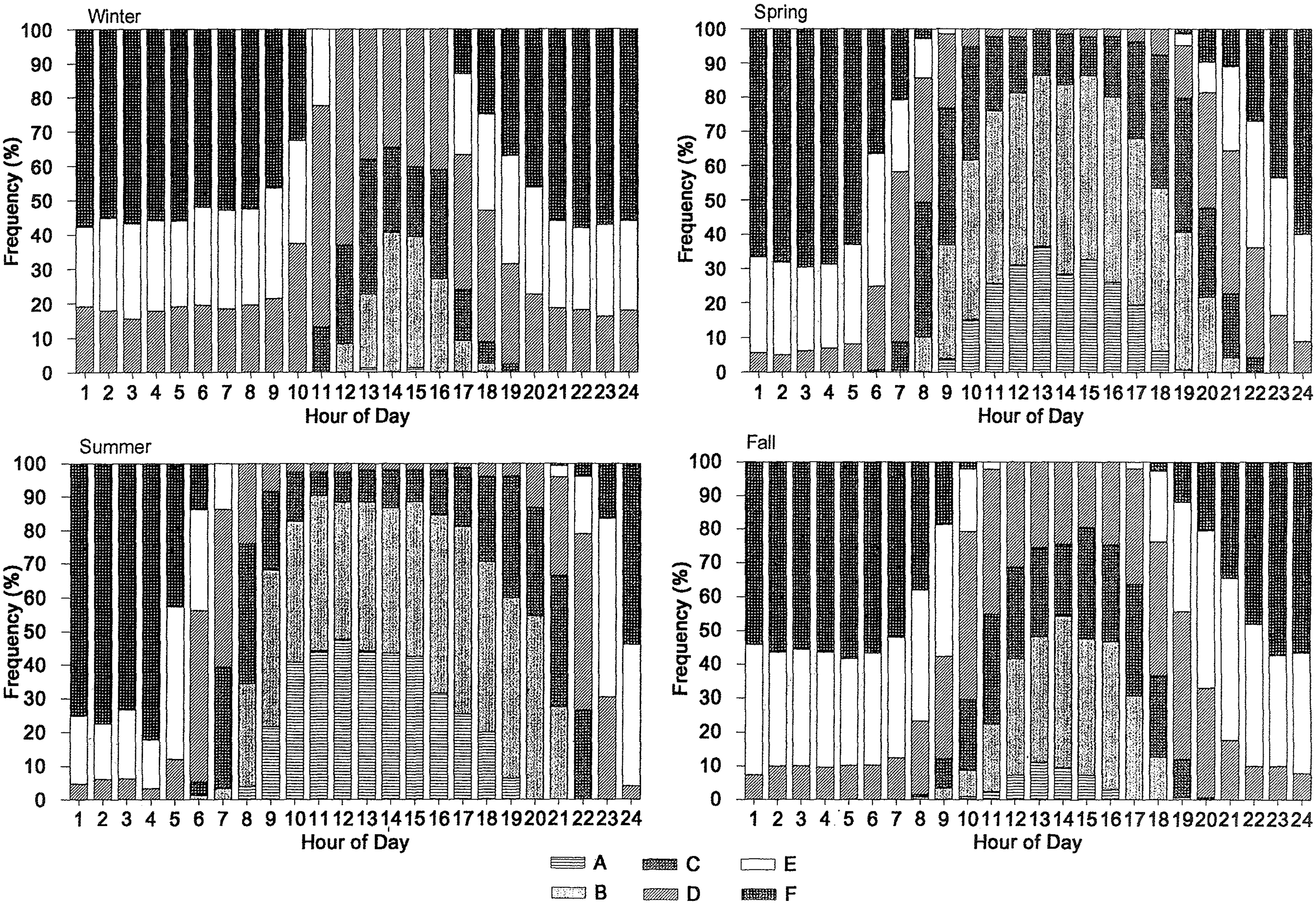


Figure 4.13 Diurnal and seasonal variation of stability class based on SandAlta data (April 1984 to March 1986).

Table 4.6 Maximum permissible levels[a] for the Province of Alberta Guidelines and Federal Air Quality Objectives.

	Alberta Guidelines	Federal Objectives		
		Desirable	Acceptable	Tolerable
SO_2 ($\mu g/m^3$)				
Annual	30 (0.01 ppm)	30	60	n/a[b]
24-hour	150 (0.06 ppm)	150	300	800
1-hour	450 (0.17 ppm)	450	900	n/a
H_2S ($\mu g/m^3$)				
24-hour	4 (3 ppb)	n/a	5[c]	n/a
1-hour	14 (10 ppb)	1[c]	15[c]	n/a
NO_2 ($\mu g/m^3$)				
Annual	60 (0.03 ppm)	60	100	n/a
24-hour	200 (0.11 ppm)	n/a	200	300
1-hour	400 (0.21 ppm)	n/a	400	1000
CO (mg/m^3)				
8-hour	6 (5 ppm)	6	15	20
1-hour	15 (13 ppm)	15	35	n/a
Oxidants ($\mu g/m^3$)[d]				
Annual	n/a	n/a	30	n/a
24-hour	50 (25 ppb)	30	50	n/a
1-hour	160 (80 ppb)	100	160	300
Total Suspended Particulates ($\mu g/m^3$)				
Annual[e]	60 (n/a)	60	70	n/a
24-hour	100 (n/a)	n/a	120	400
Static Measurements (mg SO_3^-/d/100 cm^2)				
Total Sulphation	0.5 (n/a)	n/a	n/a	n/a
H_2S	0.1 (n/a	n/a	n/a	n/a

(a) At a temperature and pressure of 25°C and 101.325 kPa, respectively.
(b) n/a = not applicable.
(c) Proposed.
(d) As ozone (O_3).
(e) As a geometric mean.

to one year. The Federal Government has established three levels of objectives (Environment Canada 1981). The levels are as follows:

- "The maximum **desirable** level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the country and for the continuing development of control technology."

- "The maximum **acceptable** level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being."

- "The maximum **tolerable** level denotes a concentration of an air contaminant that requires abatement without delay to avoid further deterioration to an air quality that endangers the prevailing Canadian life-style or ultimately, to an air quality that poses a substantial risk to public health."

In Alberta, the Environmental Protection and Enhancement Act (EPEA) provides for the development of ambient air quality guidelines. The current guidelines are applicable to concentrations of SO_2, H_2S, NO_2, CO, O_3, TSP and to static total sulphation and static H_2S (Alberta Environmental Protection 1993).

With the exception of oxidants and the proposed Federal one-hour average for H_2S, the Alberta Environmental Protection guidelines are equal to the most stringent of the Federal objectives. The Alberta guidelines for oxidants are less strict when compared to the Federal Air Quality objectives since rural ozone concentrations in Alberta can exceed the Federal Desirable Level (Angle and Sandhu 1986 1989).

Several agencies have identified ambient concentration guidelines and objectives to protect vegetation resources in addition to these specified by the Alberta and Federal governments. The International Union of Forest Research Organization (IUFRO) guidelines (Wentzel 1983 *in* WHO 1987) and the World Health Organization (1987) guidelines are based on research in Europe studying the effects of SO_2 exposures alone. The values given in Table 4.7 refer to SO_2 effects on forest and vegetation.

4.1.4.2 Deposition Loading

Deposition includes both wet and dry processes and reflects the long-term accumulation of contaminants in aquatic and terrestrial ecosystems. Deposition of sulphur and nitrogen compounds to these systems has been associated with a change in water and soil chemistry and in the acidification of water and soil. Even through there are currently no limits on the rates of deposition for the Province of Alberta, studies have been undertaken to try and define target loadings.

Table 4.7 Comparison of existing guidelines or objectives for SO_2 concentrations that are recommended to prevent injury to vegetation.

Duration	**IUFRO (forests under good growing conditions)**	**WHO (vegetation)**
Annual	Maximum annual average concentration of 0.019 ppm.	0.011 ppm
Daily	0.038 ppm not to be exceeded more than 12 times in 6 months.	0.038 ppm
Hourly	97.5% of the 30 min. average growing season values should be less than 0.056 ppm (equivalent to 0.05 ppm as a 1-hour average).	—

Wet Sulphate Deposition

The United States-Canada Memorandum of Intent (MOI) assessment document (1983) specifies a target loading value for wet sulphate deposition of 20 kg SO_4^{-2}/ha/a to protect sensitive aquatic systems. This target loading concept is based on the following:

- Sulphuric acid is the dominant compound contributing to long-term water acidification.
- The sulphate ion (SO_4^{-2}) is a reasonably good surrogate for hydrogen (H^+) ion deposition. The latter results in the acidification.
- Sensitive aquatic systems are defined as those with a surface alkalinity of less than 200 μeq/L.

For systems with a surface alkalinity greater than 200 μeq/L, higher loading rates were deemed to be acceptable.

The validity of extrapolating this target value to Western Canada has been questioned (Marmorek *et al.* 1986, Singleton *et al.* 1988, Interim Acid Deposition Critical Loadings Task Group 1990, Alberta Environment 1990). In Alberta and the rest of the Prairie Provinces, there is strong evidence to show that wet deposition is not correlated with SO_4^{-2}. If wet sulphate were acting as a good surrogate for H^+, then there would be a strong positive correlation between the two variables and a strong negative correlation between SO_4^{-2} and the pH (acidity) of precipitation (Summers 1986). In Western Canada, the very poor correlation that exists between SO_4^{-2} and H^+, and the much better correlation that exists between SO_4^{-2} and cations such as calcium (Ca^{+2}), magnesium (Mg^{+2}) and ammonium (NH_4^+), lead to the conclusion that windblown calcareous dust and SO_4^{-2} from other sources (e.g., soils) have altered the chemistry of the precipitation.

Acidifying Potential (AP)

The Interim Acid Deposition Critical Loadings Task Group (1990) defines an interim target loading based on wet deposition only. The target loading is expressed as an Acidifying Potential (AP) which is defined as:

$$AP = SO_4^{-2} - (Ca^{+2} + Mg^{+2})$$

where the individual components can be expressed in units of kmol H^+/ha/a. The Task Group report did not make it clear how the AP could be related to model predictions. For this evaluation, the following expression was used to relate the AP to model predictions.

$$\text{Acidifying Potential} = \text{Background } [SO_4^{-2} - (Ca^{+2} + Mg^{+2})] + \text{Predicted Total } [SO_4^{-2}]$$

The above expression conservatively assumes total deposition from the plant will contribute to the AP. This is a conservative assumption since the Task Group implies that only wet deposition should be used because they were unclear as to how to address dry deposition. The "Background" term can be obtained from a nearby precipitation monitoring network (e.g., Fort McMurray) while the "Predicted" term can be obtained from dispersion models (ADEPT2). The wetfall deposition is usually expressed in units of kg/ha/a. One kg SO_4^{-2} /ha/a is equivalent to 0.021 kmol H^+/ha/a.

The committee recommended an interim critical range of 0.12 to 0.31 kmol H^+/ha/a to protect highly sensitive ecosystems. It appears that this interim range is based on protecting sensitive lake systems.

Effective Acidity (EA)

The Alberta Environment (1990) review for setting deposition limits in Alberta recommends that a target loading be based on the Effective Acidity (EA) approach. The exact relationship for Effective Acidity can vary with the ecosystem. To assess the effect of stack emissions on soils, Alberta Environment (1990) recommends the use of the soil EA based on the Coote *et al.* (1982) relationship combined with a term for additional deposition:

$$\text{Effective Total Acidity} = \text{Wetfall } [H^+ + 1.15\ NH_4^+ - 0.7\ NO_3^-] + \text{Predicted Total } [SO_2]$$

The total effective acidity is also expressed in units of kmol H^+/ha/a. The Alberta Environment (1990) report did not make it clear how the EA could be related to model predictions. For this evaluation, the "Wetfall" term was obtained from a nearby precipitation monitoring network and the "Predicted" term was obtained from dispersion model predictions as the expected total SO_4^{-2} deposition. The predicted SO_2 deposition is expressed in SO_4^{-2} equivalent kg/ha/a. One kg SO_4^{-2}/ha/a is equivalent to 0.021 kmol H^+/ha/a.

The Alberta Environment (1990) review defines three sensitivity classes for soil and aquatic systems and preliminary deposition limits for each class:

Soil Sensitivity Class	Effective Acidity Deposition Limit (kmol H+/ha/a)
Low	0.7 to 1.0
Medium	0.3 to 0.4
High	0.1 to 0.3

Aquatic Sensitivity Class	Alkalinity (mg/L)	Effective Acidity Deposition Limit (kmol H+/ha/a)
Low	> 21	> 0.3
Medium	11 to 20	> 0.3
High	0 to 10	0.1 to 0.3

4.1.4.3 Background Ambient Air Quality

A considerable amount of ambient air quality monitoring has been undertaken in the Athabasca oil sands area. The locations closest to the Solv-Ex site include the following:

- Bitumount Tower is located 7 km to the east of the proposed Solv-Ex facility. Data for the period February 1977 to April 1980 have been summarized in Strosher (1978, 1981).

- SandAlta is located 22 km to the southeast of the proposed Solv-Ex facility. Data for the period 1981 to 1984 have been summarized in reports prepared by Morrow and Murray (1982), Hansen (1985) and Hansen (1986).

- Fort McKay is located 20 km to the south of the proposed Solv-Ex facility. Data from the period 1989 to 1993 have been collected by AEP and summarized in their annual reports (AEP 1989, 1990, 1991, 1992, 1993).

While the existing operators also maintain ambient air quality monitoring trailers in the vicinity of their respective operations, the background analysis was limited to the three above mentioned sites due to their closer proximity to the Solv-Ex site.

Bitumount Tower

The Bitumount station was instrumented to measure SO_2, H_2S, CO, NO_x, NO_2, O_3 and HC concentrations on a continuous basis. Additional Hi-volume sampling was conducted to measure TSP and metal content of TSP.

During the period May 1977 to December 1979 (32 months) the following were observed at Bitumount:

- **SO_2 concentrations**. Values greater than 0.34 ppm were observed 2 times, values between 0.17 and 0.34 ppm were observed 4 times and values between 0.06 and 0.17 ppm occurred 192 times. These relatively high values were associated with the start up of the Syncrude facility. These values are expressed as one-half hour averages.

- **O_3 concentrations**. The overall maximum hourly value was 130 ppb with maximum hourly values being typically in the 30 to 75 ppb. Maximum 24 hour values were in the 27 to 83 ppb range.

- **NO_2 concentrations**. The overall maximum hourly value was 0.11 ppm with maximum hourly values being in the 0.01 to 0.05 ppm range.

- **NO_x concentrations**. The overall maximum hourly value was 0.65 ppm with maximum hourly values being in the 0.02 to 0.10 ppm range.

- **CO concentrations**. The overall maximum hourly and 8 hourly values were 10 and 3.71 ppm, respectively. The maximum hourly values are typically in the 0.0 to 1.50 ppm range. Similarly, the maximum 8 hourly value are typically in the 0.13 to 1.0 ppm range.

These results (from Strosher 1981) indicate that relatively high concentrations have been observed in the area. Some of these values were attributed to the start up of a second oil sands plant (i.e., Syncrude). In addition, it should be noted that the portable electrical generator located 130 m from the site was identified as a probable cause of some of elevated NO_2, NO_x and CO concentrations observed at the site.

SandAlta

The SandAlta station was instrumented to measure SO_2, O_3 and NO_2 on a continuous basis. The maximum hourly values (as a one-hour average) and the mean values observed at 4 and 22 m are summarized in Table 4.8 for the period when the station was operated by the Research Management Division. The main findings of the study indicated:

- The largest SO_2 concentrations were observed during the daytime (0800 to 1800). No apparent seasonal trends were observed. SO_2 concentrations in excess of the air quality guidelines were observed.

- The largest O_3 concentrations were observed during the spring season. The maximum spring values were associated with daytime hours 0800 to 1800.

- The largest NO_2 values were associated with daytime hours with no significant seasonal trends. NO_2 concentrations were much lower than the ambient air quality guidelines.

Again, the results indicate that larger SO_2 concentrations can occur in the area due to existing industrial activity. As a generator was not used to provide electrical power, the maximum NO_x and NO_2 concentrations were less than those observed at Bitumount.

Fort McKay

Continuous monitoring has been conducted by Alberta Environment in Fort McKay since 1983. This station, which is located 20 km to the south of the Solv-Ex site, monitors H_2S, SO_2 and total hydrocarbons (THC). The period from 1989 to 1993 was evaluated using the data published annually by AEP. The following were observed at Fort McKay during this period:

- **H_2S Concentrations.** The maximum for the five year period was 0.011 ppm as a 1-hour average, resulting in one exceedence.

- **SO_2 Concentrations.** A total of 11 hourly exceedences were recorded over the five years with the maximum being 0.475 ppm. In all cases, winds were from the south and southeast suggesting the operations of the existing oil sands facilities as the source.

- **THC Concentrations.** The maximum hourly concentration recorded for the period was 5.9 ppm. No trends were observed for the area.

Table 4.8 Maximum and mean ambient concentrations observed at SandAlta.

		March 1984 to March 1985	April 1985 to March 1986
SO_2 (22 m)			
Maximum	(ppm)	0.100	0.250
Mean	(ppm)	0.003	0.003
SO_2 (4 m)			
Maximum	(ppm)	0.150	0.250
Mean	(ppm)	0.003	0.003
O_3 (22 m)			
Maximum	(ppb)	80	84
Mean	(ppb)	21	26
O_3 (4 m)			
Maximum	(ppb)	60	80
Mean	(ppb)	22	15
NO_2 (22 m)			
Maximum	(ppm)	0.050	0.020
Mean	(ppm)	0.001	0.000
NO_2 (4 m)			
Maximum	(ppm)	0.040	0.020
Mean	(ppm)	0.001	0.000

Summary

The following table summarizes the survey of the three data sources to yield the ambient background concentrations of SO_2 and NO_2:

Source	Period	Mean Background Concentration	
		SO_2 (ppm)	NO_2 (ppm)
Bitumount	1977 - 1980	0.002	0.003
SandAlta	1984 - 1986	0.003	0.000
Fort McKay	1989 - 1993	0.003	n/a

These values suggest that there has been little change in the background concentration of SO_2 over a 13-year period. No trend can be observed for NO_2. The average value for the period is 0.003 for both contaminants. These background values are within the "noise range" of the analysis and, as such, they are of limited value. For the purpose of this assessment, the background value was taken as twice the average observed ambient value, as in:

SO_2 (background)	0.006 ppm (16 $\mu g/m^3$)
NO_2 (background)	0.006 ppm (11 $\mu g/m^3$)

4.1.4.4 Background Precipitation Chemistry

Alberta Environmental Protection and Environment Canada maintain a network of precipitation chemistry stations at selected locations in Alberta. Although some of these data are collected at the Fort McKay station, they are too infrequent to be representative. The most recent precipitation chemistry data for Fort McMurray (the period 1989 to 1993) were obtained from Alberta Environment. The average pH, deposition rates of selected ions and calculated Acidifying Potential (AP) and Effective Acidity (EA) for each year and the period mean are shown in Table 4.9. While the 1990 to 1993 data have been quality controlled, the results from 1989 are based on raw data. From this, the average current background AP and EA are used to estimate the cumulative effect associated with the operation of the proposed Solv-Ex facility. These two values were added to the respective predictions from the ADEPT2 model to estimate the cumulative effect of the deposition. This is anticipated to be conservative due to the fact that the background precipitation chemistry should already account for some of the anthropogenic effects in the vicinity (i.e., Suncor and Syncrude). The background values are as follows:

AP (background)	0.02 kmol H^+/ha/a
EA (background)	0.07 kmol H^+/ha/a

Table 4.9 Fort McMurray precipitation chemistry statistics based on AEP data from 1989 to 1993.

	pH	H^{+}(a)	SO_4^{-2}	NO_3^-	NH_4^-	Ca^{+2}	Mg^{+2}	AP(b)	EA(c)
		kg/ha/a (kmol H^+/ha/a)						(kmol H^+/ha/a)	
1989 (6)(d)	4.79	0.085 (0.084)	6.5 (0.067)	2.0 (0.030)	0.5 (0.025)	0.8 (0.019)	0.2 (0.007)	(0.04)	(0.09)
1990 (10)	5.08	0.037 (0.037)	6.3 (0.065)	3.3 (0.054)	0.5 (0.029)	1.8 (0.045)	0.6 (0.026)	(-0.01)	(0.03)
1991 (12)	4.85	0.083 (0.082)	6.0 (0.063)	3.7 (0.060)	0.7 (0.039)	1.0 (0.025)	0.2 (0.008)	(0.03	(0.08)
1992 (12)	4.72	0.061 (0.061)	4.5 (0.047)	1.7 (0.028)	0.5 (0.025)	0.4 (0.011)	0.1 (0.004)	(0.03)	(0.07)
1993 (12)	4.68	0.068 (0.067)	5.3 (0.055)	1.7 (0.028)	0.5 (0.030)	1.1 (0.028)	0.3 (0.012)	(0.02)	(0.08)
Mean	4.70	0.066	5.7	2.5	0.5	1.0	0.3	(0.02)	(0.07)

(a) Calculated from the pH and period rainfall.

(b) Calculated from the formula by Interim Acid Deposition Loadings Task Group (1990):
$AP = [SO_4] - [Ca^{+2} + Mg^{+2}]$

(c) Calculated from the formula by Alberta Environment (1990):
$EA = [H^+] + 1.15\ [NH_4] - 0.7\ [NO_3]$

(d) Number of months of available data; values are prorated to one year.

4.1.5 *Background Noise*

No ambient noise levels have been measured at or near the proposed Solv-Ex facility. The level of background noise at the proposed site can probably be characterized as that associated with a wilderness setting.

4.2 Terrain and Geology

4.2.1 *Relief and Topography*

Most of the Local Study Area is part of the Muskeg River Plain, a subdivision of the Great Slave Plain, except for the Fort Hills Upland to the east, which is part of the Methy Portage Plain (Turchenek and Lindsay 1982).

Level to gently undulating topography is typical of much of the area, with slopes of 10 degrees or less. Overall, the terrain slopes to the west towards the Athabasca River.

Figure 4.14 illustrates the elevation relationship between the proposed plant site, the main incinerator stack and the Athabasca River valley. The proposed final plant site elevation is estimated at 285 m ASL. Elevation variations within the plant site boundaries will be minimal. To the north, two terrain features are of note: Fort Hills rise to approximately 360 m ASL, 4 km to the northeast of the Calumet uplands reach about 340 m ALS, 6 km to the northwest of the opposite side of the Athabasca River. The Birch Mountains are at a peak elevation of 800 m approximately 25 km northwest of the site. Muskeg Mountain rises slowly to an elevation of 580 m ASL, 60 km to the southeast of the proposed site. Figure 4.15 shows the topography of Lease 5.

Figure 4.16 shows a conceptual cross-section showing the relationship of the mine to the river. A drilling program in the summer of 1995 will define geotechnical and groundwater characteristics of the Athabasca river bank. This will provide the data required to ensure stability of the river bank and to prevent water interchange between the mine and the river.

The influence of trees on air flow is dependent on such factors as tree height and uniformity of the cover. The Mixedwood Ecoregion is mosaic by forest associations with white spruce, black spruce, jack pine, balsam fir, tamarack, aspen, balsam poplar and white birch and mature heights ranging from 10 to 30 m.

4.2.2 *Bedrock Geology*

Lower Cretaceous near surface bedrock underlies the Local Study Area (McPherson and Kathol 1977). These strata comprise from oldest to youngest the following:

- McMurray Formation oil sand, with minor siltstone and claystone.

- Clearwater Formation marine shale and glauconitic sandstone (basal Wabiskaw Member), of variable thickness.

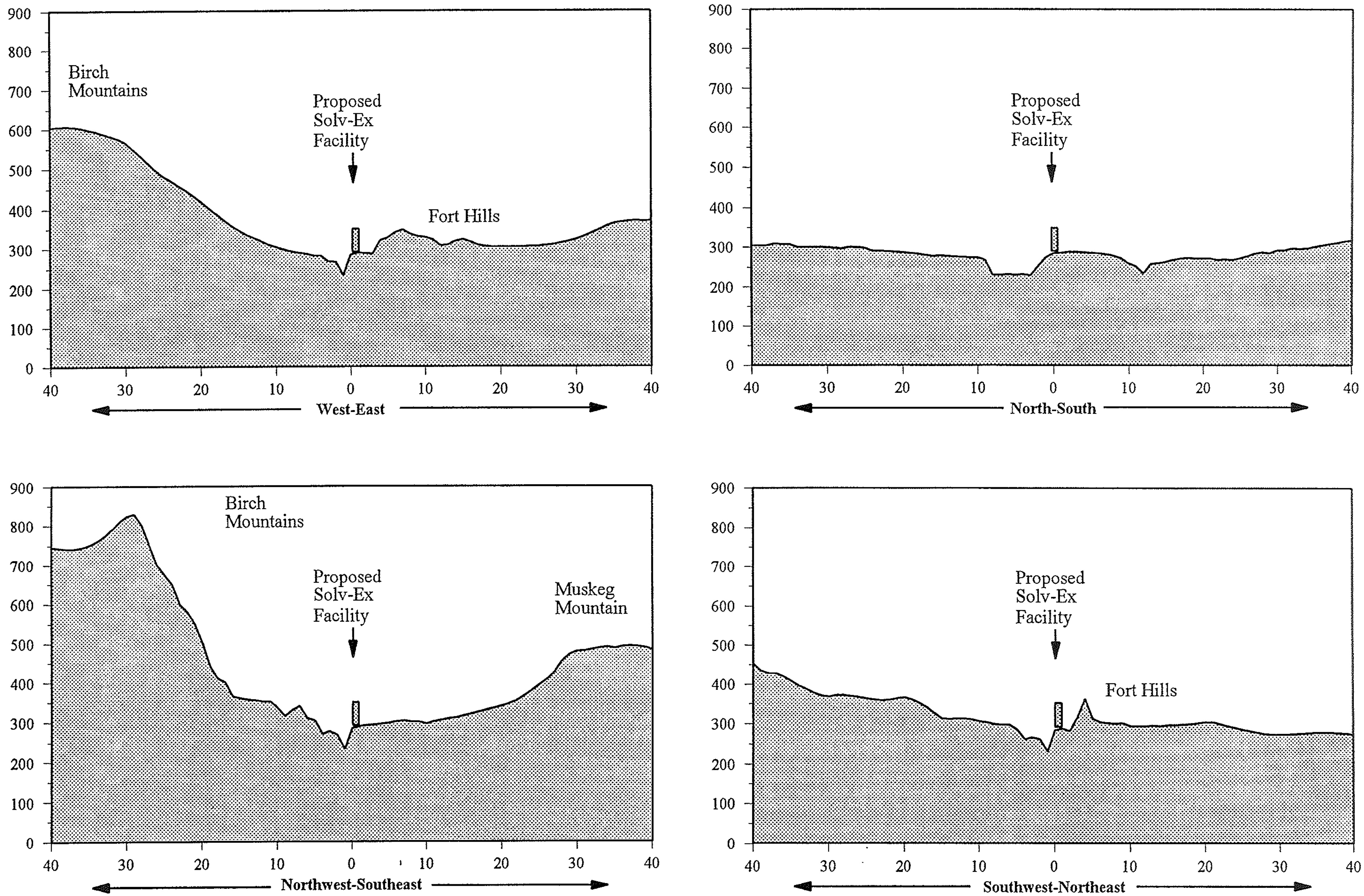


Figure 4.14 Terrain elevation as a function of distance from the proposed Solv-Ex facility (km).

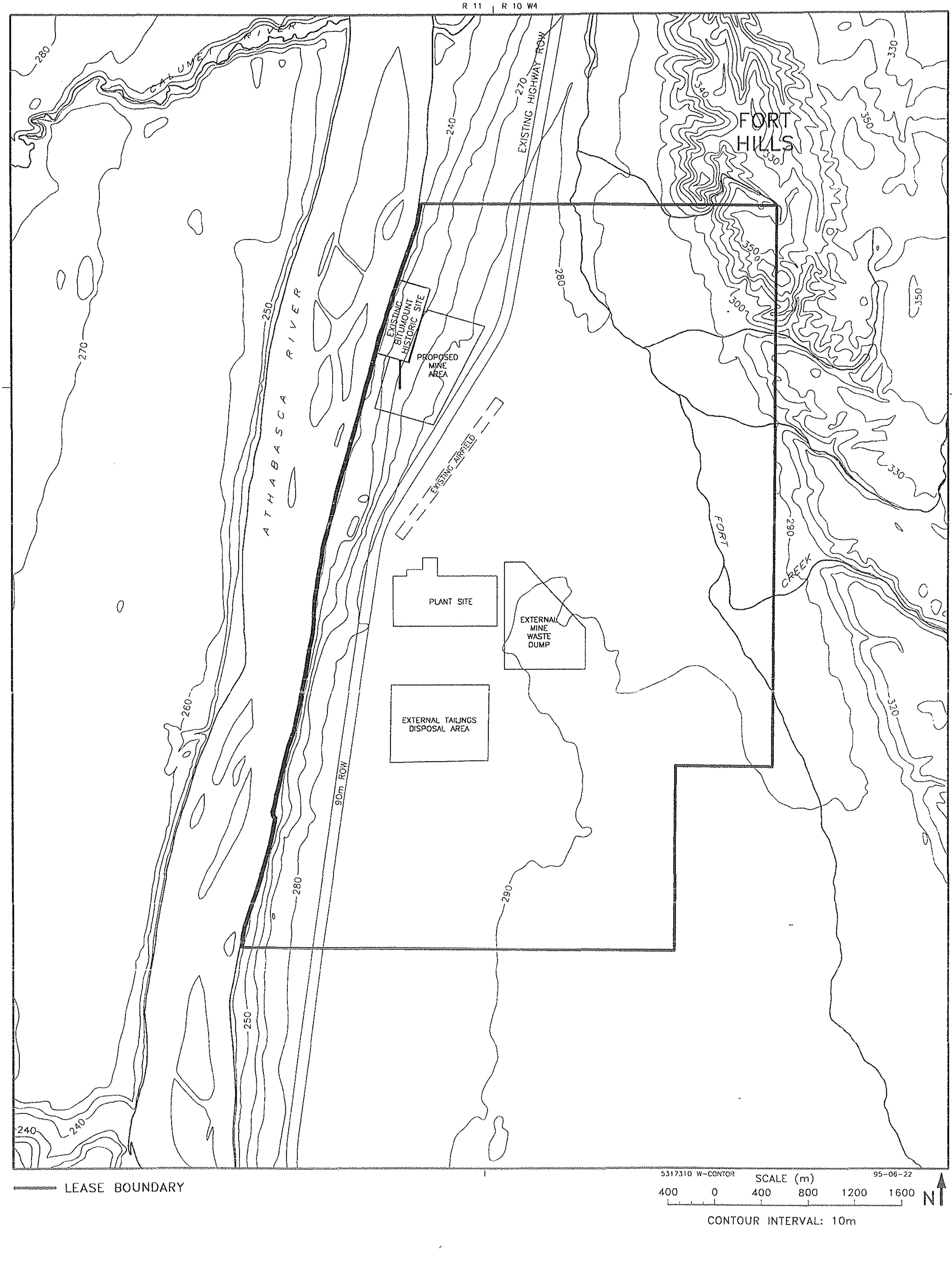


FIGURE 4.15 TOPOGRAPHIC MAP

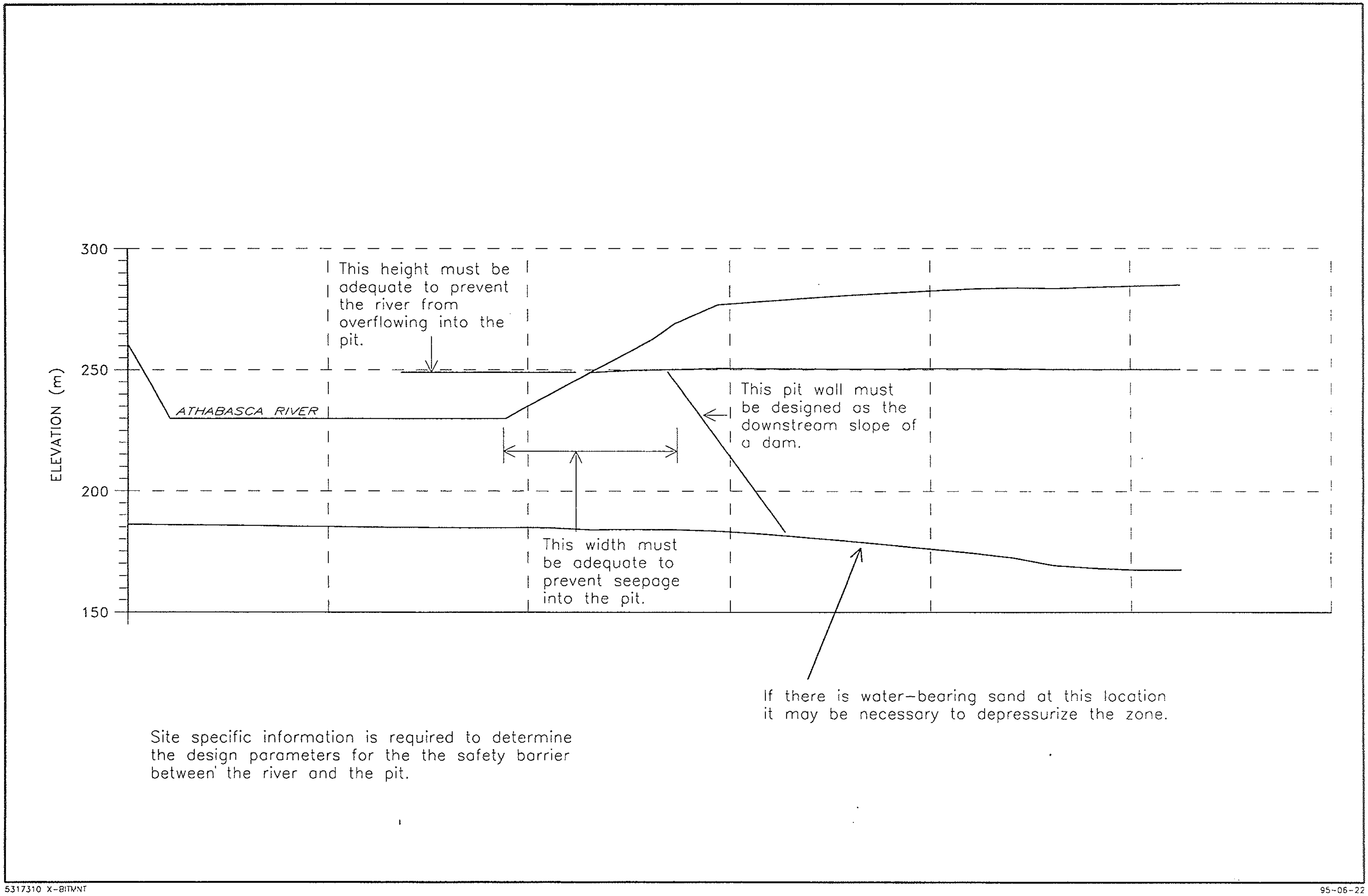


FIGURE 4.16 SCHEMATIC TOPOGRAPHIC CROSS-SECTION THROUGH BITUMOUNT

Both units are assigned to the Mannville Group and represent a transition from continental fluvial to offshore marine depositional conditions. Flach (1984) reviewed the oil sands geology of the oil sands area in detail. Table 4.10 summarizes the general stratigraphy of the oil sands region.

In the Local Study Area, bedrock exposures are found in outcrops along the Athabasca River and creek valleys and in natural bedrock exposures in the north (Turchenek and Lindsay 1982). Figure 4.17 illustrates the bedrock geology of the Local and Regional Study Areas.

4.2.3 *Surficial Geology*

Information on surficial materials and landforms in the Local Study Area was compiled based on air photo interpretation and a review of existing reports, i.e., Bayrock (1971), McPherson and Kathol (1977), Thompson *et al.* (1978) and Turchenek and Lindsay (1982).

Two main glacial deposits are predominant in the Local Study Area:

- Glaciofluvial-outwash-eolian overlay; composed predominantly of sand, with almost no silt or clay. Eolian activities have reworked some of the glaciofluvial sands into sand dunes and sheets (Turchenek and Lindsay (1982), and

- Ice-contact deposits such as kames and kame moraines in the Fort Hills area.

Holocene materials that have developed since the area was deglaciated, include:

- Recent alluvium, forming floodplains and terraces along the Athabasca River and Fort Creek,

- Organic bogs, fens and veneers, and recent lacustrine sediments infilling terrain depressions, and

- Colluvial slopewash that veneers and blankets the western slopes of the Fort Hills, around the banks of Fort Creek and adjacent to the Athabasca River.

4.2.4 *Significant Natural Terrain Features in the Local Study Area*

D.A. Westworth & Associates Ltd. (1990) have identified and assessed the significance of terrain features, as part of a larger study of natural features in the Eastern Boreal Forest Region of Alberta. Three areas of significance are mapped in or adjacent to the Local Study Area:

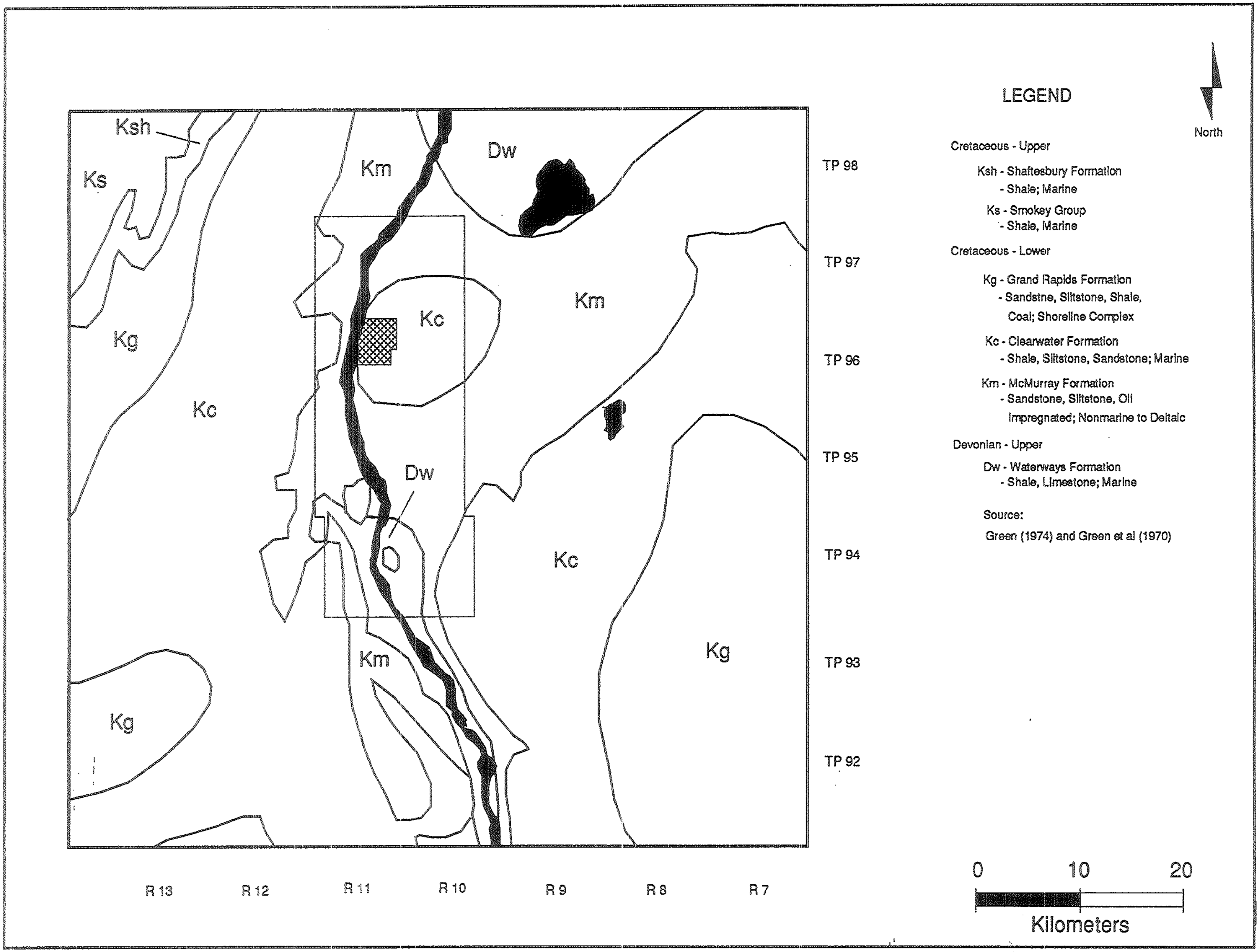
- The Fort Hills, for the occurrence of high landform diversity, and
- The Athabasca River, a feature of national significance.

Table 4.10 Subsurface Stratigraphic Column for the Oil Sands Region.

System or Series	Formation	Member	Lithology	Depositional Environment
Pleistocene and Recent			Peat and organics, clay sand, silt, gravel and till	Variable
		Erosional unconformity		
Lower to Upper Cretaceous	Colorado Group		Shale	Marine-Deltaic
	Labiche*		Sandstone	Marine
	Pelican			
Lower Cretaceous	Joli Fou		Shale	Marine
	Mannville Group		Lithic sand and sandstones, thin coals	Shore Line
	Grande Rapids			
Complex	Clearwater	Wabiskaw	Glauconitic sandstone	Marine
	McMurray		Quartzrose sand impregnated with heavy oil	Continental
		Erosional unconformity		
Upper Devonian	Woodbend Group			
	Grosmont		Limestone reef, dolomite	Marine
	Ireton		Shale and limestone	Marine
	Cooking Lake		Limestone	Marine
	Beaverhill Lake Group			
	Waterways	Mildred	Argillaceous Limestone	Marine
		Moberly	Limestone	
		Christina	Calcareous shale	
		Calumet	Clastic limestone	
		Firebag	Argillaceous limestone	
		Paraconformity		
	Slave Point	Caribou	Limestone, dolomite, minor gypsum and shale	Marine-Evaporitic
		Paraconformity		
Middle Devonian	Elk Point Group			
	Prairie Evaporite		Anhydrite and salt	Evaporitic
	Methy		Reefal dolomite	Marine
	McLean River		Dolomite, claystone and evaporite	Marine-Evaporitic
	LaLoche		Arkosic sandstone, claystone and conglomerate	Continental
		Erosional unconformity		
Precambrian			Granite, gneiss and metasediments	

* The Labiche Formation, according to Green (1972), is laterally equivalent to the Shaftesbury (shale) and Dunvegan (sandstone and shale) Formations and Smoky Group (shale).

Sources: Carrigy (1973), Green (1972), Green *et al.* (1970) and Norris (1973).



gure 4.17 Bedrock Geology in the region.

4.3 Soils

A 1:20 000 soil map (Figure 4.18) has been prepared for the Local Study Area based on:

- Airphoto interpretation of 1986 1:40,000 photography, and
- A review of published soils information for the surrounding area that includes: Concord Environmental Corporation (1991) and Hardy Associates (1981).

Turchenek and Lindsay (1982) mapped soils in the Local Study Area as part of the Alberta Oil Sands Environmental Research Study Area (AOSERP) at a scale of 1:126 720. This report was used a basis for establishing soil associations during the airphoto interpretation phase of the study.

The soil maps identify soil associations that include the dominant soil type that occupies greater than 40% of the map unit and other significant soil type(s) that occupy between 20 and 40% of the polygon. The soil associations within the Local Study Area are presented in Table 4.11. Complex polygons with two soils types were divided using the following assumptions: the dominant soil type was assumed to cover 60% of the polygon area and the significant soil type was assumed to cover 40%.

4.3.1 *Parent Materials and Soil Associations*

4.3.1.1 Organic Parent Materials and Soil Associations

Organic deposits are the dominant soil parent materials within the Local Study Area. The great majority of organic deposits (73%) are developed from the accumulation of bog materials. Fennic deposits occupy approximately 27% of the organic soil parent materials. The majority of the organic deposits were assumed to be less than 160 cm thick and are underlain predominantly by glaciofluvial deposits. Three soil associations that occur on very poorly drained organic deposits were mapped.

On bog organics, two Kenzie (KNZ) soil associations were mapped. The Kenzie soil associations occur on level to nearly level (0.5 to 2.0% slopes), very poorly drained, weakly to moderately decomposed moss peat landforms. Vegetation is dominantly black spruce, Labrador tea and mosses.

Kenzie soils are extremely acidic to neutral, contain high levels of organic carbon and comparatively low levels of nitrogen, generating very high Carbon/Nitrogen ratios. Cation exchange capacities are also very high.

- The Kenzie 1 map unit represents organic soils on deeper deposits. These soils are dominantly Typic and Fibric Mesisols developed on 100 to 250 cm of bog peat. Also present as significant soils (20 to 40% occurrence) are Mesic and Fibric Organic Cryosols (soils affected by permafrost). Kenzie 1 soils occupy 18% of the organic soil types, and approximately 5% of the Local Study Area.

Table 4.11 Parent materials and soil associations in the Local Study Area.

Parent Material	Soil Series	Soil Unit	Dominant Soils	Dominant Vegetation	Drainage Class	Surface Expression	Texture	Area (ha)	Percent (%) of Local Study Area
Glacio fluvial	Mildred 1	MIL1	Dystric Brunisol	Aspen-Jack Pine	Well	Undulating: 2-9% slopes	sl-ls	2217	50
	Mildred 2	MIL2	Dystric Brunisols	Aspen-Jack Pine	Well to Imperfect	Undulating: 2-9% slopes	sl-ls	103	2
	Haight	HGT	Orthic and Rego Gleysols	Black Spruce	Very Poorly	Level-undulating: 1-5% slopes	ms-sl	181	4
Glacio fluvial/aeolian	Bitumont	BMT	Peaty Gleysol	Black Spruce	Poorly	Level-undulating 1-5% slopes	peat	437	10
Ice contact deposits	Firebag 1	FIR1	Eluviated Dystric Brunisol	Jack Pine-Aspen	Rapidly	Humocky 2-15% slope	sl	81	2
	Firebag 2	FIR2	Eluviated Dystric Brunisols	same as above	Very Rapidly	Hummocky 6-30% slope	sandy, boulders	139	3
Colluvial/glacio fluvial	Buckton	BKN	Orthic Regosol	Jack Pine	Well-rapidly	6-40% slope	sl	50	1
Organic	Kenzie 1	KNZ 1	Typic and Fibric Mesisols	Black Spruce-Sphagnum	Very poorly	Level 0-2% slope	peat	214	5
	Kenzie 2	KNZ2	Terric Mesisol	Black Spruce Sphagnum	Very poorly	Level-undulating 0-5% slope	peat	651	15
	Eaglesham	EGL	Typic and Fibric Mesisols	Sedges, Marsh Reeds, Willow	Very poorly	Level 0-2% slope	peat	324	7
Disturbed	Disturbed	DS	N/A	N/A	N/A	N/A	N/A	26	1
TOTAL								4423	100

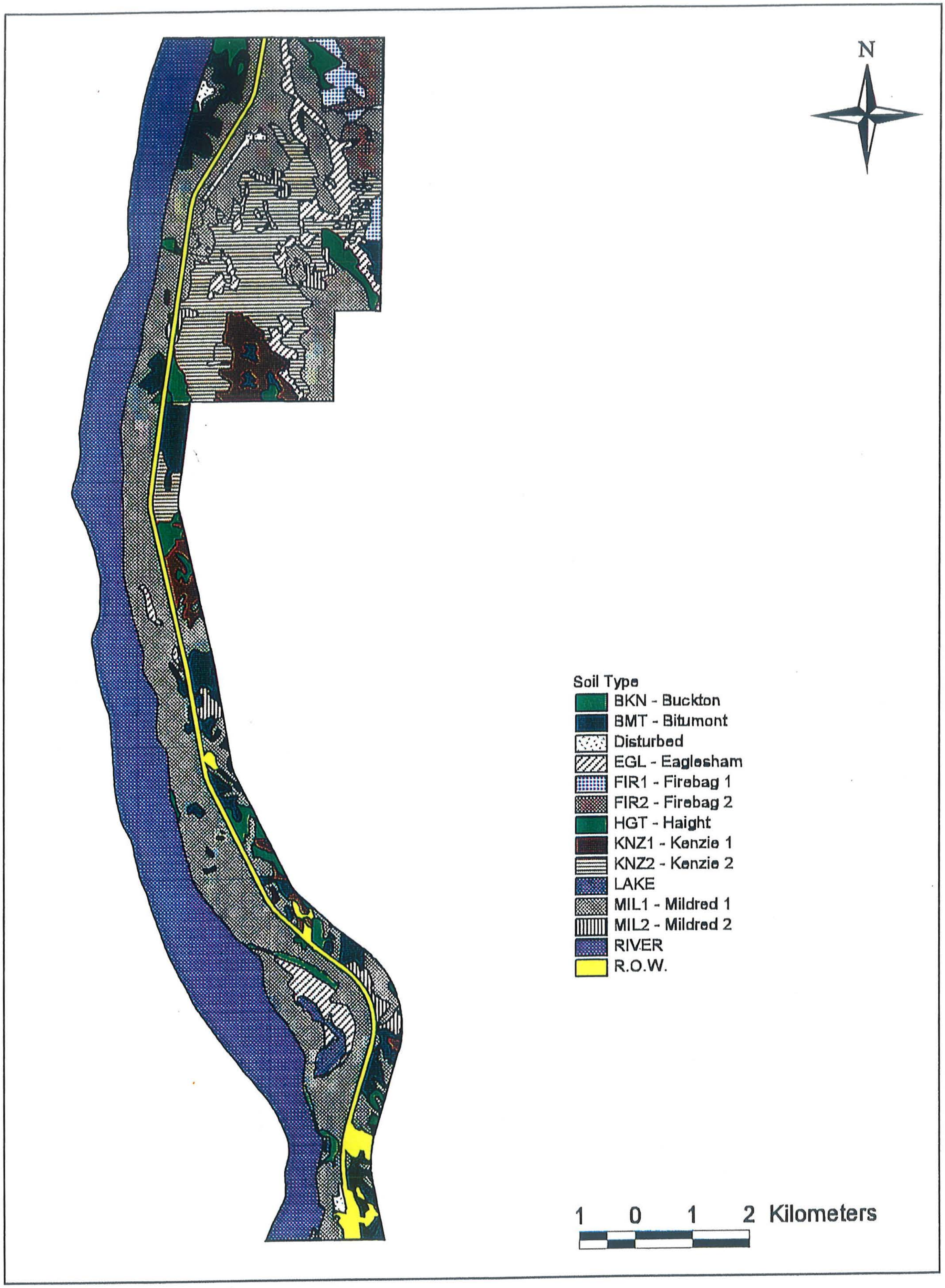


Figure 4.18 Soil Associations of the Local Study Area.

- The Kenzie 2 soil association is the most common of all the organic soil types occupying 55% of the organic landforms and 15% of the entire Local Study Area. The Kenzie 2 soil unit is dominantly Terric Mesisols developed on 25 to 80 cm of bog peat. Also present as significant soils (20 to 40% occurrence) are peaty Rego Gleysols that have developed in areas where the organic deposits are less than 40 cm.

Eaglesham soil associations occur on level to nearly level (0.5 to 2.0% slopes), very poorly drained, weakly to moderately decomposed fen organics. Vegetation is generally composed of sedge grasses, bog birch, willow and tamarack. Eaglesham soils are moderately to slightly acidic, with high level of organic carbon and relatively low levels of nitrogen, generating a large Carbon/Nitrogen ratio. Cation exchange capacities are large with approximately 80% of the exchange sites being occupied by bases.

- The Eaglesham soil association is mapped on the deeper fen organics (60 to 120 cm) and is dominantly composed of Terric Mesisols. Present as significant soils (20 to 40% occurrence) are Terric Fibric Organic Cryosols exhibiting permafrost within the upper metre. The Eaglesham soil association occupies approximately 27% of the organic parent material soils and 7% of the Local Study Area.

4.3.1.2 Mineral Parent Materials and Soil Associations

Within the Local Study Area, three mineral soil parent materials have been recognized. Sandy textured glaciofluvial deposits are the most dominant of the mineral soil parent materials occupying 71% of the Local Study Area. The other two mineral soil parent materials, ice contact deposits, and colluvial-glaciofluvial combined cover to 5% of the Local Study Area (Table 4.11).

Glaciofluvial Deposits

Glaciofluvial deposits in the Local Study Area are sand textured with a strongly to slightly acidic reaction. Cation exchange capacities are low, as are levels of organic carbon and nitrogen. Glaciofluvial deposits support a black spruce-aspen community in moist landscape positions and a pine-aspen cover in drier upland topographical positions. Soils are dominantly Brunisolic lacking the clay to be eluviated/illuviated common to the Luvisolic soils occurring on glaciolacustrine deposits.

- The Mildred Lake soil associations (MIL 1 and MIL 2) represent deep glaciofluvial deposits. Mildred Lake 1 is the drier of the two units containing Eluviated Dystric Brunisols (pH< 5.5) as the dominant soil type and Eluviated Eutric Brunisols (pH > 5.5) as significant soils. The Mildred Lake 2 unit contains the same dominant soil type but include imperfectly drained Gleyed Eluviated Dystric Brunisols and poorly drained peaty Rego Gleysols (Bitumont soil series). These soil associations occupy 52% of the Local Study Area.

- The Bitumount soil association has been used to describe dominantly peaty Rego Gleysols developed on glaciofluvial deposits. The Bitumont soil associations comprise 10% of the Local Study Area.

Ice Contact Deposits

Ice contact deposits occur where the Fort Hills encroach on the Local Study Area and occupy 5% of the Local Study Area. Parent material characteristics consist of sandy, moderately to exceedingly stony, glaciofluvial ice contact deposits on a kame moraine. Lenses of clay, till and coarse sand and gravel can be present as inclusions (Turchenek and Lindsay 1982). These materials support stands of jack pine and aspen.

- Two Firebag soil associations have been mapped in the Local Study Area. They are both Eluviated Dystric Brunisols with significant inclusions of Eluviated Eutric Brunisols and Gleyed subgroups of these soil types. The Firebag 1 soil association occurs on lower slopes of the Fort Hills (2-6% slope), while Firebag 2 occurs on upper slope positions (6-30% slope).

Colluvial and Glaciofluvial Deposits

Colluvial/glaciofluvial deposits occur next to the Athabasca River, Fort Creek and adjacent to the Fort Hills. The parent material is a mixture of geologic materials due to slumping. The materials are generally sandy and gravelly in the Local Study Area. Vegetation consists of jack pine and aspen.

- The Buckton soil association is an Orthic Regosol with significant inclusions of Eluviated Dystric Brunisols. Slopes range from 10 to 40%.

4.3.2 *Soil Capability for Agriculture*

The soil capability for agriculture for the Local Study Area is presented in Figure 4.19. Soil capability ratings were undertaken for each mapping unit using the document Land Capability Classification for Arable Agriculture in Alberta (Alberta Soils Advisory Committee 1987*b*).

The results of the analysis shows that no soils of the Local Study Area are suitable for viable agriculture due to climatic and soil limitations (Table 4.12). Of the Local Study Area, about 57% has very severe limitations for agriculture (Class 5), 14% has extremely severe limitations (Class 6) and 29% (Class 7) are not useful for viable agriculture.

Table 4.12 Soil capability for agriculture of the soils of the Local Study Area.

Soil Associations	Soil Unit	Dominant Soils	Soil Capability for Agriculture
Mildred 1	MIL 1	Dystric Brunisol	5 m[a]
Mildred 2	MIL 2	Dystric Brunisols	5 m
Haight	HGT	Orthic and Rego Gleysols	5 w
Bitumont	BMT	Peaty Gleysol	6 w
Firebag 1	FIR1	Eluviated Dystric Brunisol	6 tm
Firebag 2	FIR2	Eluviated Dystric Brunisols	7 t
Buckton	BKN	Orthic Regosol	5 m - 7 t
Kenzie 1	KNZ 1	Typic and Fibric Mesisols	7 w
Kenzie 2	KNZ 2	Terric Mesisol	7 w
Eaglesham	EGL	Typic and Fibric Mesisols	7 w

[a] Subclasses:
m - a low moisture holding capacity
w - excess water
t - adverse topography

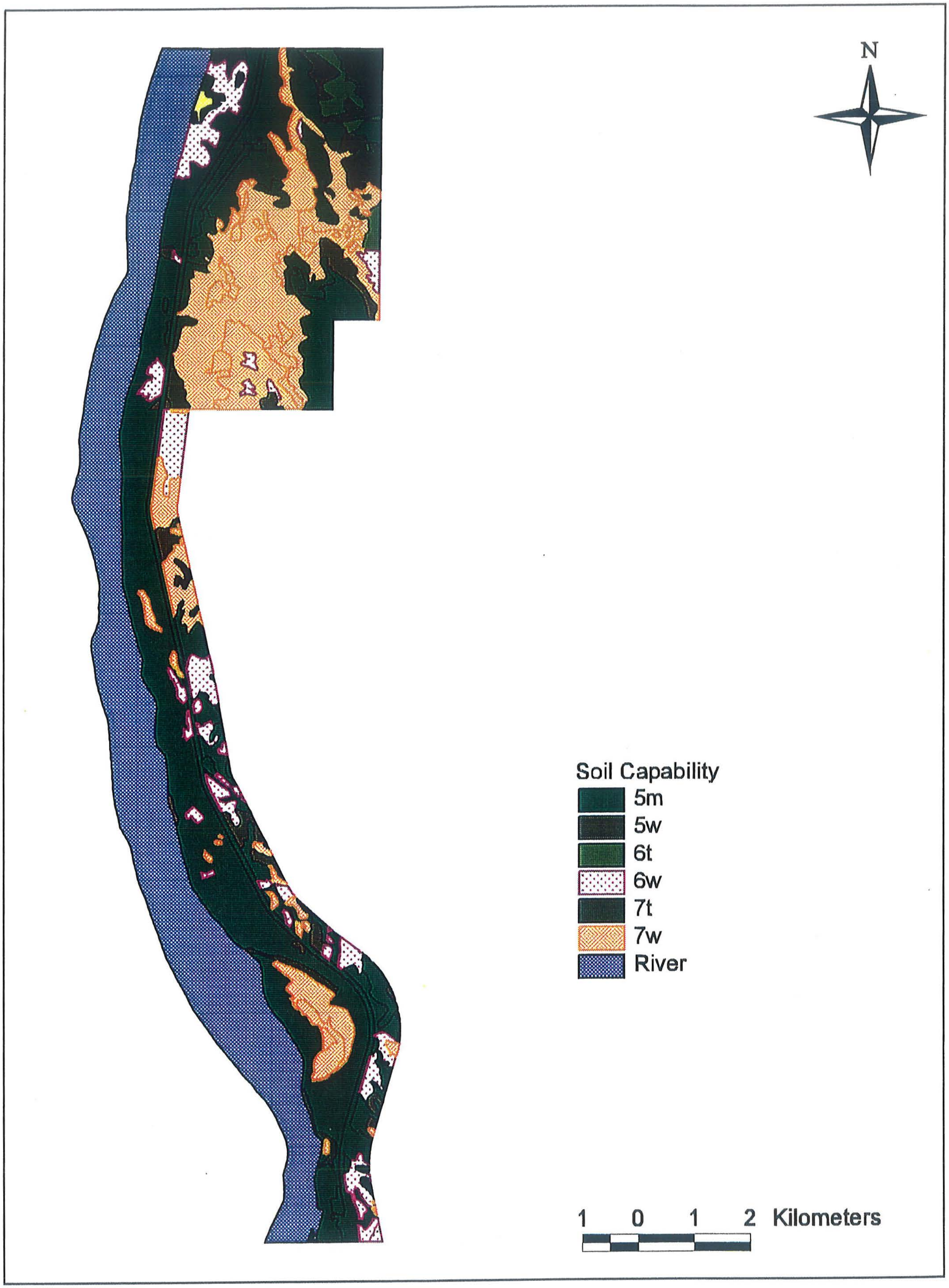


Figure 4.19 Soil Capability of the Local Study Area.

4.3.3 *Sensitivity of Soils to Acidifying Emissions*

A system for classifying the sensitivity of soils to potential acidification based on soil reaction (pH) and cation exchange capacity has been developed (Holowaychuk and Fessenden 1987). The classification system is as follows:

- **High Overall Sensitivity** — Soils with a pH less than 4.6
  Soils with a cation exchange capacity < 6 meq/100 g, and a pH > 4.6 and < 6.5.

- **Moderate Overall Sensitivity** — Soils with a cation exchange capacity between 6 and 15 meq/100 g and a pH between 4.6 and 6.0.

  Soils with a cation exchange capacity > 15 meq/100 g with a pH between 4.6 and 5.5.

- **Low Overall Sensitivity** — Soils with a pH > 6.5 regardless of cation exchange capacity.

  Soils with a pH > 6.0 and a cation exchange capacity > 6 meq/100 g

Based on the Holowaychuk and Fessenden (1987) system, the soils in the vicinity of the Solv-Ex plant have a range of sensitivities to acidification, from low to high (Table 4.13). The Mildred soil series is classified as having a low to moderate sensitivity, the Eaglesham a moderate sensitivity, and the Kenzie and Firebag soil series high overall sensitivities. The soil series that are classified as having a low overall sensitivity include Bitumont, Buckton and Haight.

Glaciofluvial deposits are the mineral soil types most sensitive to acid deposition, due to their very strongly to medium acid soil reaction (pH) and very low cation exchange capacities (< 6 meq/100g). The low CEC is due to the lack of clay size particles in glaciofluvial materials and the low levels of organic matter in surface horizons. Since the Haight soil association has a peaty horizon over glaciofluvial sands with a high Cation Exchange Capacity, this soil association would have a low potential for acidification.

Holowaychuk and Fessenden (1987) also developed a rating system for organic soil sensitivity to acidic deposition, based on pH, exchangeable bases and percent base saturation of the organic material, and pH and calcium and magnesium contents of waters contained in the organic deposits. Based on these parameters, organics are grouped into one of three peatland systems:

- Eutrophic (nutrient rich) peatland systems are characterized by relatively high pH and base cation contents and, therefore, high buffering capacities. They have a low overall sensitivity to acidification.

Table 4.13 Sensitivity of soils to acidic deposition.

Soil Association	Cation Exchange Capacity (me/100 g)[a]	pH[a]	Soil Sensitivity to Acidification[b]
Bitumount	70 to 90	5.5 to 6.9	Low
Buckton	< 6	6.4 to 7.3	Low to Moderate
Eaglesham	70 to 90	5.9	Moderate
Firebag 1 and 2	< 6	4.6 to 5.5	High
Haight	130	7.9	Low
Kenzie	70 to 90	4.1 to 5.9	High
Mildred 1 and 2[a]	2	6.4 to 7	Low to Moderate

[a] Hardy Associates (1981) and Graecam (1992).
[b] Hollowaychuk and Fessenden (1987).

- Oligotrophic (low nutrient status) peatland systems have very low pH and base cation contents. The relative loss of bases and the likelihood of lowering the inherent extremely acidic soil reaction (pH) is low. Although the sensitivity to Al solubilization is high, the low sensitivity of the two other soil processes results in a low overall sensitivity to acid deposition.

- Mesotrophic (moderate nutrient status) peatland systems exhibit a moderately high to low buffering capacity. Strong acidic additions will rapidly deplete the buffering capacity and progressively reduce the remaining buffering capacity. Mesotrophic peatlands are highly sensitive to acidification and base loss, and moderately sensitive to aluminum solubilization. The overall sensitivity category is high.

Within the organic soil map units the Kenzie soil association is expected to be highly sensitive to acidification, while the more humified, less acidic map units of the Eaglesham and Bitumount soil associations are rated as having a low potential for acidification.

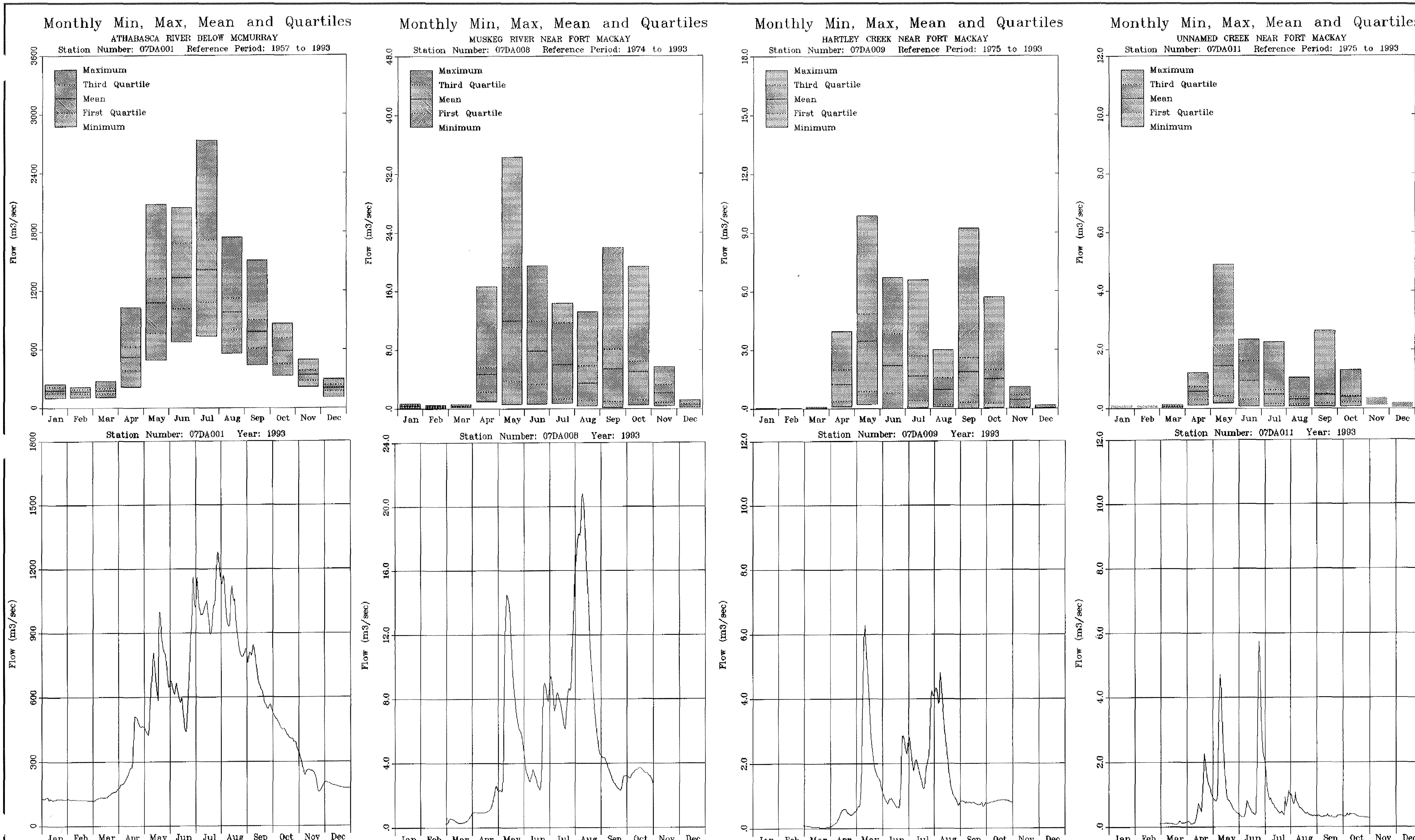
4.3.4 *Soil Suitability for Reclamation*

The soil associations in the Five Year Development Area for the Experimental Project were evaluated in light of their suitability for use in reclamation based on soil chemistry data from soil surveys (Graecam Enterprises 1990, Turchenek and Lindsay 1982). The Alberta Soil Advisory Committee (ASAC 1987*a*) suggests that soil should be salvaged for reclamation in two lifts within the Northern Forest region of Alberta. It is probable that salvage of suitable materials at the Solv-Ex site will be conducted as one lift with the exception of peat which will be handled separately. For this reason, the criteria utilized to evaluate suitability is taken for the upper lift materials. Evaluation criteria (soil reaction [pH], salinity [electrical conductivity] and calcium carbonate content) are marginally more stringent for upper lift materials than lower lift materials. Other soil quality criteria are similar between lift layers.

The soil quality criteria of salinity and sodicity as outlined by ASAC (1987*a*) are not expected to be limiting factors to reclamation suitability for the upper lift soils. The soil criteria of consistency is slightly limiting and has been accounted for through the textural limitations for glaciofluvial veneers and blankets.

Organic soil, which covers the greatest area of the Local Study Area, is not rated for use as a revegetation soil. However, organic soil could be salvaged and used as soil amendment to increase the cation exchange capacity and the water holding capacity of the mineral soil (ASAC 1987*a*). The suitability of an organic material as a soil amendment is dependent upon the degree of decomposition of the material. The greater the decomposition, the greater the ability of the organic matter to contribute to the reclaimed soil and the greater the likelihood of attaining an even distribution of the organic material in the root zone. Positive characteristics of organic matter, such as high cation exchange capacity (which is a measure of inherent soil fertility and high moisture holding capacity), far outweigh the limitations such as low pH and a high percent saturation.

Well humified organic materials such as Typic and Terric Humisols are good soil amendment materials. Moderately decomposed organic materials such as Typic and Terric Mesisols are fair



Regional Hydrologic Data
Figure 4.20

amendment materials, while slightly or weakly decomposed organic materials representative of Typic and Terric Fibrisols are fair to poor. The majority of the organic soil, that is the Kenzie and Eaglesham units, in the Local Study Area are likely to have fair suitabilities as reclamation amendment materials due to the moderate stage of decomposition and acidic pH.

The probable suitability of mineral soils within the 5 Five Year Development Area for reclamation is summarized in Table 4.14. The ratings are tentative since no site-specific soil information is available for the Local Study Area. The glaciofluvial and ice contact deposit soil parent materials are mainly limited by coarse texture and low pH.

- A 1 m lift of Bitumont soil with an organic veneer overlying sandy textured glaciofluvial deposits will likely range from a fair to poor suitability for reclamation. The reclamation suitability will be fair if textures are not sands or loamy sands.

- The Mildred and Firebag soils developed on a veneer to blanket of sandy textured glaciofluvial material have a fair to unsuitable suitability for reclamation. Soil reaction (pH) is generally fair to good throughout the glaciofluvial material, while the loose consistency is considered to be a slight limitation. Stoniness could be the main limitation in these soils. The suitability of the Mildred and Firebag soils can be upgraded to fair by amending the material with organic matter or soil with finer textures.

The Haight soil association would have a fair to unsuitable rating for reclamation. The main limiting factors could be high pH in some horizons. The low percent saturation of the B horizon could be altered by admixing with the organic horizon.

4.4 Surface Water

4.4.1 *Water Quantity*

The location of the proposed Solv-Ex Project relative to Fort Creek and Athabasca River, is as shown on Figure 2.1. Fort Creek will not be affected by the project and thus baseline data for it is not presented. Water will be withdrawn from and discharged into the Athabasca River.

Monthly recorded flow patterns for the Athabasca River downstream of Fort McMurray for the period 1957 to 1993, inclusive (the most current published data flow) are illustrated in Figure 4.20. Year-to-year and season-to-season variations are significant as the river flow responds to rainfall and snowmelt events in its very large and diverse watershed extending all the way back to Jasper National Park in the Canadian Rockies. Day-to-day open water flow variations are relatively minor in a large river system such as the Athabasca. During spring breakups, flow and water level variations can be rapid especially as the result of the formation and breakup of ice jams in the project to Fort McMurray reach of the river. Downstream of Environment Canada's flow monitoring station at Fort McMurray, the Suncor and Syncrude operations are presently licensed to withdraw 30 and 62 million m^3 of water annually respectively. This is equal to a total average withdrawal rate of 2.9 m^3/sec.

Table 4.14 Suitability of soils in the Solv-Ex Local Study Area for reclamation.

Soil Criteria	Mildred[a] 1 and 2			Haigt[b]			Firebag[c]			Bitumont[c]		
	Horizon	Value	Rating	Horizon	Value	Rating	Horizon	Value	Rating	Horizon	Value	Rating
pH	Ae	6.4-7.0	F-G	Omk	7.9	NR	Ae	4.6-5.5	F-G	Om		NR
	Bm	6.4-7.5	F-G	Bmkg	8.5	U	Bm	5.6-5.9	G	Bg	6.5	G
	BC	6.4-6.5	G	BCkg	7.9	P	BC	4.8-6.4	G-F	Ckg	7.3	F
	IICk	6.7-7.7	F-P									
Percent Saturation	Ae	N/A	N/A	Omk	243	NR	Ae	22.5-37.6	F-G	Om		NR
	Bm	N/A	N/A	Bmkg	9	U	Bm	17.4-29.0	F	Bg	34.0	G
	BC	N/A	N/A	BCkg	15	P	BC	19.5-29.5	F	Ckg	36.0	G
	IICk	47-71	G-F									
Texture	Ae	LS-SL	P-G	Omk	NA	NR	Ae	S-LS	P	Om		NR
	Bm	S-LS	P	Bmkg	SL	G	Bm	S-SL	P-G	Bg	S-SL	P-G
	BC	SL-SCL	G-F	BCkg	SL	G	BC	S-LS	P	Ckg	S-SL	P-G
	IICk	SCL-C	F-P									
$CaCO_3$	Ae	NC***	G	Omk	NA	NR	Ae	NC	G	Om		NR
	Bm	NC	G	Bmkg	11.2	F	Bm	NC	G	Bg	NC	G
	BC	NC	G	BCkg	13.6	F	BC	NC	G	Ckg	5.8	F
	IICk	3.8-12.6	F									
Suggested Rating for 1 M Lift****			F-P			P-U			F-P			F-P

(a) Graecam Enterprises 1992
(b) Hardy Associates 1981
(c) Graecam 1990

Mineral soils are rated for reclamation suitability, organic as a soil amendment.

NR= Not Rated
NC= Non Calcareous

Recorded flow data by Environment Canada for the Muskeg, Hartley and No Name watersheds (Figure 4.20), can be used, as baseline data for impact assessments for the small drainage in the plant site area. These three watersheds are considered to be most comparable to this small, local, on-site watershed. Monthly flow patterns and most current year hydrographs are shown on Figure 4.20.

Figure 4.21 illustrates the relationships between flow and drainage area for the regional recorded data for 1:2 year to 1:100 year intervals. Via extrapolation, this data is sufficient to compute design flows for structures such as the Highway 63 culverts.

4.4.2 *Water Quality*

4.4.2.1 Regional Suspended Sediment

Suspended sediment in rivers and streams follow a seasonally cyclic pattern. Concentrations of suspended materials are high during high flow periods (snowmelt and summer floods), followed by low concentrations of suspended sediment during low flow summer or winter periods. A detailed evaluation of sediment transport data for the Lower Athabasca River was carried out by Carson and Associates (1989) for the Water Resources Branch of Environment Canada (Figure 4.22).

The Athabasca River has sediment measuring stations at Fort McMurray and Embarras Airport. Sediment sampling at Fort McMurray began in 1967 and has been ongoing at the present site since 1973. The peak concentration recorded (since 1973) was 4110 mg/L in June 17, 1973 at a flow of 2096 m^3/sec and the minimum was 4 mg/L in February 3, 1978 at a flow of 206 m^3/sec. The mean concentration is about 350 mg/L. Periods of high turbidity are generally of short duration; concentrations exceeding 1000 mg/L usually exist for less than ten days a year. Concentrations during the fall and winter months are very low, usually 20 mg/L. The data is as summarized on Figure 4.23.

Environment Canada's stream sediment stations on tributary streams of the Athabasca River are not "full program stations" and as such have only miscellaneous data. The data shows that there are regional differences in mean concentrations which are probably due to differences in the geology and physiography of the basins. The Muskeg River and Hartley Creek stations show much lower mean concentrations (< 20 mg/L) than other tributary systems. The Muskeg River and Hartley Creek exhibit little or no downcutting (Carson & Associates 1989). The monitoring sites on these two rivers are also located below vast, marshy, slow moving stream channel sections, which are ideal as settlement basins.

4.4.2.2 Chemical Constituent Data

Water quality in the Athabasca River generally changes little between the site located upstream of the Muskeg River and the downstream Embarras Airport site. This indicates that the intervening tributary inflows are not having a significant impact on river quality conditions. The greatest trend in river water quality is seasonal. Particulate related parameters, i.e., suspended solids, total phosphorus, iron and manganese decline in the winter as the river's suspended load declines.

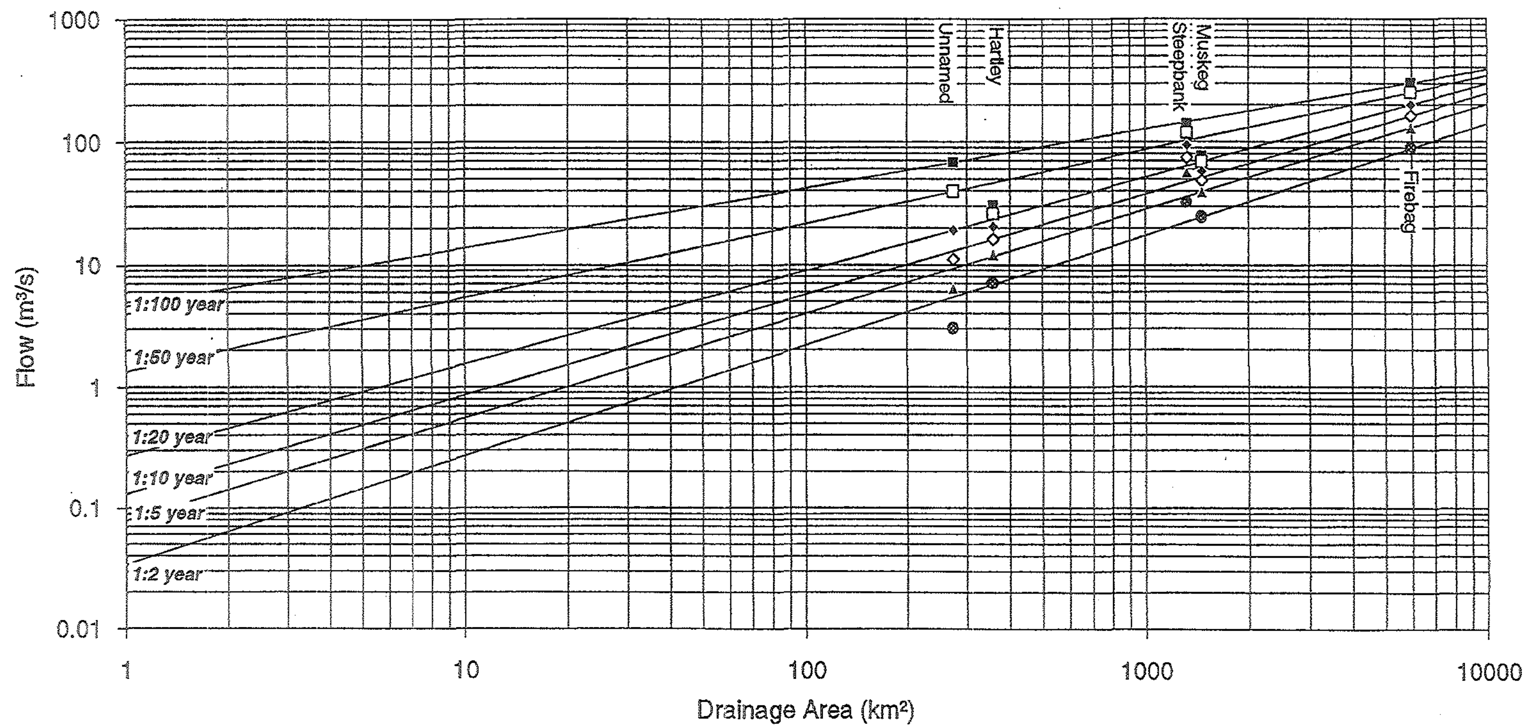


Figure 4.21 Regional flood frequency analysis.

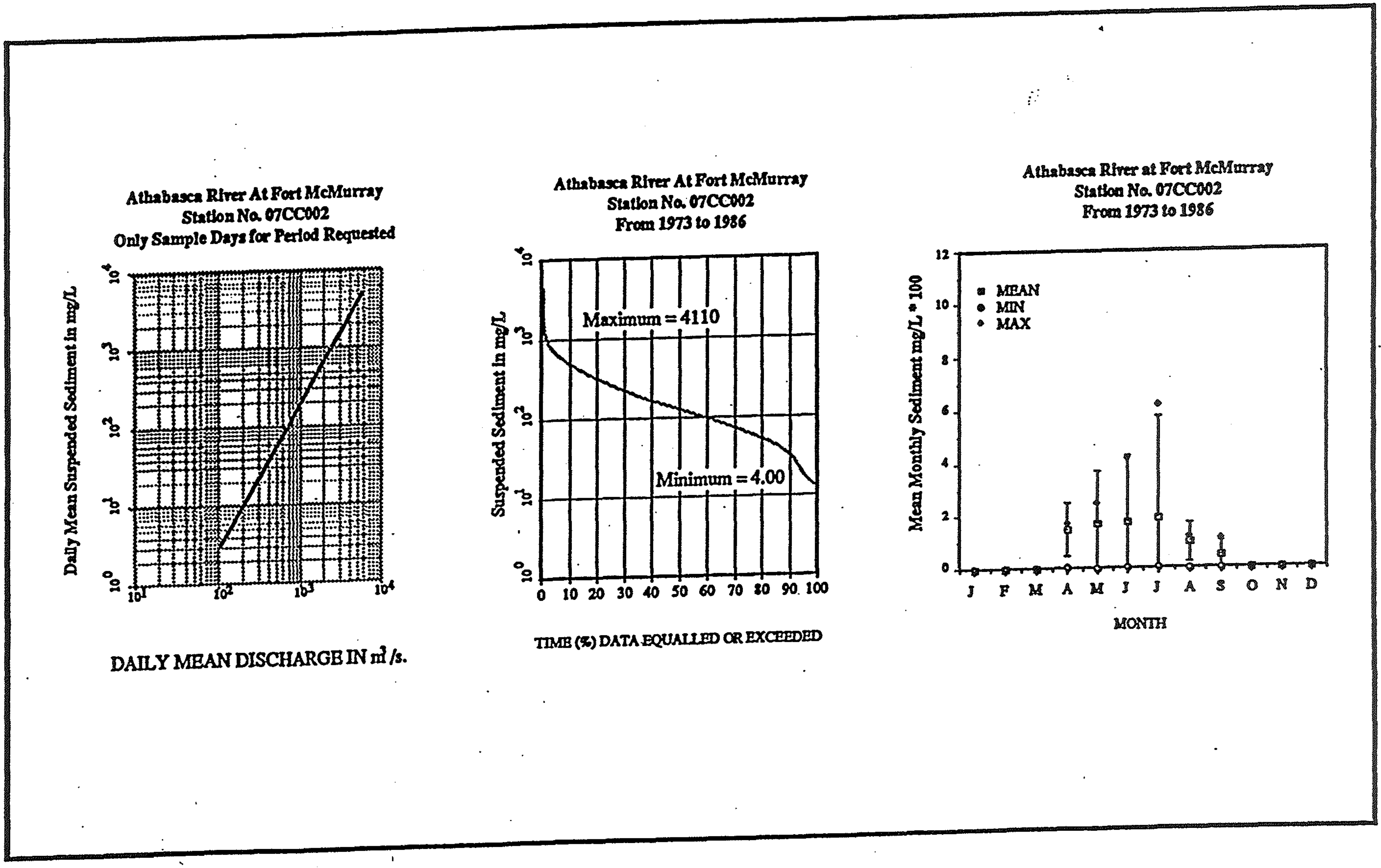


Figure 4.22 Sediment concentration and yield in the Athabasca River at Fort McMurray.
Source: Carson & Associates (1989).

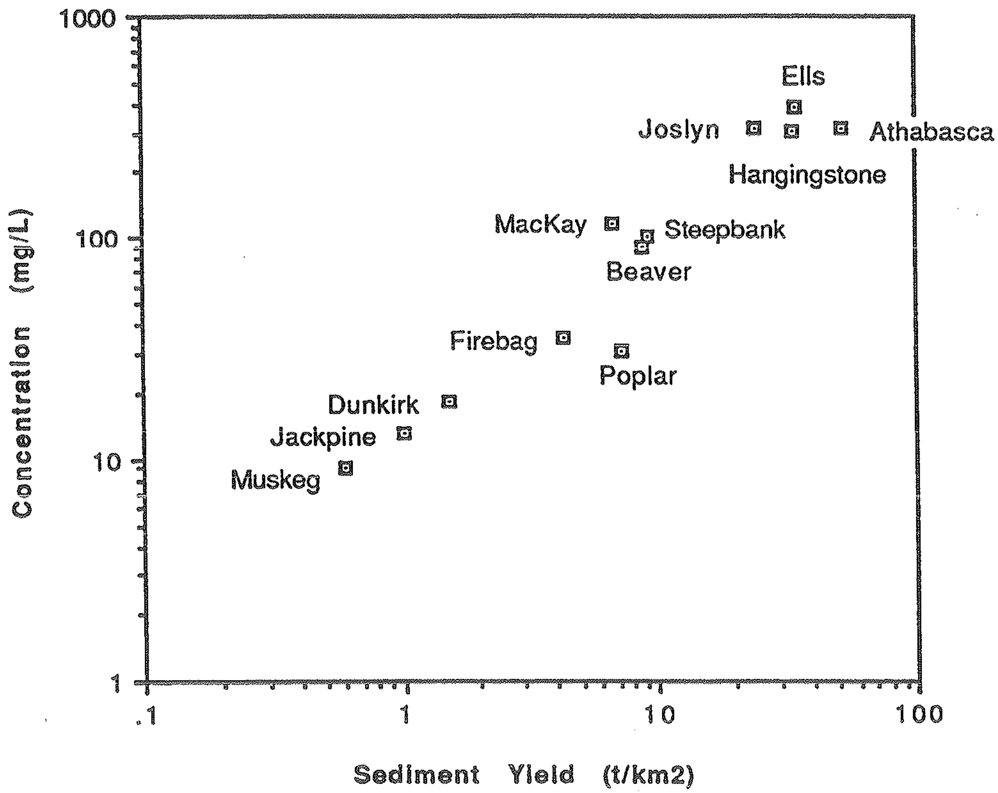


Figure 4.23 Average annual sediment concentration and yield within watersheds in the Regional Study Area. Source: Carson and Associates (1989). Note: Jackpine Creek is commonly known as Hartley Creek.

While under ice, the major ions and inorganic nitrogen forms tend to increase slightly. Data is as summarized in Table 4.15.

4.4.2.3 Sensitivities to Acidification

In 1987 Alberta Environmental Protection initiated a program of sampling and testing waterbodies in northeastern Alberta for sensitivity to acidification (Figure 4.24); "Because of their close proximities to high emissions of SO_2 and NO_x from oil sands plants...lakes in the Birch Mountains Upland, Muskeg Mountain Upland, Firebag Plains, and Athabasca Plains were selected for the initial study" (Trew 1995). Based on pH, total alkalinity and calcium, Alberta Environmental Protection has identified aquatic ecosystems potentially sensitive to acidic deposition in Alberta (Erickson 1987). Within the Regional Study Area, waterbodies in the Birch Mountain Uplands/ Namur Lake area (northwest corner) and the region of the Muskeg Mountain Uplands are categorized as sensitive to moderately sensitive to acidification (Figure 4.24). The remainder of the region is classified as having low sensitivity. More specifically, as shown in Table 4.16, total alkalinity values indicative of high (< 10 mg/L) or moderate (11 to 20 mg/L) sensitivity, as defined by Erickson (1987), were recorded in summer, winter or both, for 4 of the 35 lakes that are located in the Regional Study Area. These waterbodies (L4, L7 and L39), are located in peatland areas of the Muskeg Mountain uplands.

4.5 Hydrogeology and Groundwater

4.5.1 *Aquifers*

The regional hydrogeology of the Local Study Area is described in Alsands Energy Ltd. (1981), and Hackbarth and Nastasa (1979). Five aquifers occur in the study area: surficial, McMurray, Basal, Methy and La Loche.

4.5.1.1 Surficial Aquifer

These aquifers are usually unconfined. Groundwater in this aquifer is perched within the glacial deposits and depth to groundwater surface is typically less than 10 m below ground surface. Groundwater flow from this aquifer likely flows laterally into the Athabasca River or laterally into natural surface drainage areas, and then into the Athabasca River. Groundwater in these aquifers has low mineralization.

4.5.1.2 McMurray Aquifer (Oil Sands)

These aquifers are represented by thin discontinuous layers of silty sands with low bitumen saturation. Hydraulic conductivity values for the oil sands will be predominantly between 1×10^{-5} and $3.2 \ 10^{-8}$ m/s (Clark 1960). Hackbarth and Nastasa (1979) states that significant regional groundwater flow does not take place through the oil sands. Groundwater quality tests conducted for the Alsands site indicted that the groundwater pH varies from 7.6 to 8.3, total dissolved solids (TDS) ranges from 846 to 2148 mg/L, chloride and sodium less than 70 mg/L and 600 mg/L,

Table 4.15 Regional water quality data and water quality objectives (all values in mg/L unless indicated otherwise).

Parameter	Athabasca River							
	Open			Ice			Water Quality Objectives	
	Min	Med[e]	Max	Min	Med[e]	Max	Alberta[a]	Canada[b]
Salinity (Total Dissolved Solids)	115	125	250	180	200	280		500[b]
Nitrogen	0.25	0.60	3.30	0.42	0.60	1.00	1.00	
Phosphorus	0.005	0.007	1.40	0.05	0.04	0.23	0.05	
Ammonia	0.00	0.05	0.76	0.005	0.11	0.35		1.0 (pH 7) 2.0 (pH 8.5)
Iron	0.30	1.50	12.00	0.30	0.50	1.00	0.30	0.30
Magnesium	5.00	7.50	14.50	10.00	12.50	14.50	0.05	0.05[c]
Aluminum	0.03	0.51	2.36	0.01	0.05	0.28		0.10
Lead	0.003	0.025	0.08	0.00	0.002	0.016	0.05	2-4 mg/L
Zinc	0.002	0.008	0.183	0.00	0.007	0.04		0.03
Vanadium	0.00	0.001	0.014	0.00	0.001	0.01		
Boron	0.02	0.08	0.20	0.00	0.035	0.18	0.50	
Hydrocarbons	0.10	0.80	2.90	0.10	0.70	3.30	Substantially absent no irredescent sheen	Not detectable[d] by sight or odour

(a) Alberta Environment (1977).
(b) CCREM (1987).
(c) Standard and Domestic Water Use.
(d) Standard for Aesthetics and Recreation.
(e) Med is Median.

Sources: Concord Environmental (1991).

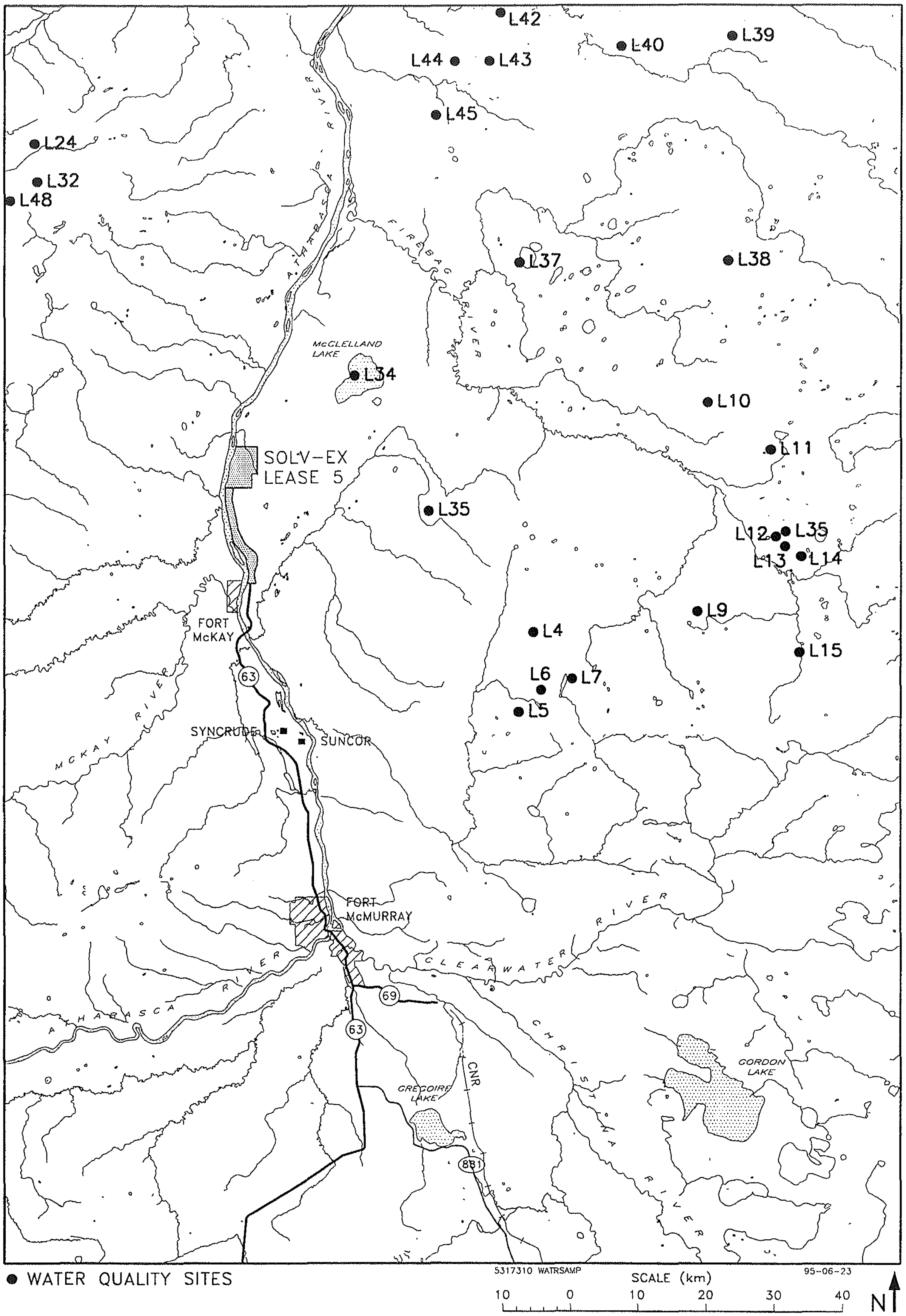


FIGURE 4.24 ALBERTA ENVIRONMENTAL PROTECTION WATER QUALITY SITES IN THE AIR RESOURCES CUMULATIVE EFFECTS STUDY AREA

Table 4.16 Water quality data for lakes in the Regional Study Area (1988 and 1992 data).

No.	Lake	pH (Units)		Total[a] Alkalinity (mg/L $CaCO_3$)		Total Phosphorous (µg/L)		Chlorophyll *a* (µg/L)	
		Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
L4	Muskeg Mtn	6.44	5.9	10.4	11.98	40	14.6	6.7	0.3
L5	Unnamed	7.02	6.90	31.10	51.09	70.8	22.2	40.6	6.2
L6	Unnamed	7.65	7.24	51.50	222.56	70.7	41.0	29.5	2.0
L7	Unnamed	6.65	6.06	13.1	19.47	25	19.8	5.7	0.4
L9	Unnamed	8.98	7.48	92.0	175.75	89.6	80.1	27.4	1.8
L10	Unnamed	8.92	7.34	75.46	140.70	15.5	6.3	3.7	4.5
L11	Unnamed	9.23	6.43	27.02	89.61	71.1	50.9	21.6	27.7
L12	Unnamed	8.16	7.01	40.28	126.26	65.6	52.7	11.4	2.8
L13	Unnamed	8.32	6.98	38.75	74.90	46.1	28.7	12.0	4.6
L14	Unnamed	9.69	7.04	58.38	151.94	106.1	77.4	29.6	29.0
L15	Unnamed	7.47		25.50		128.4		45.9	
L24	Eaglenest	7.49		33.65		130.2		9.9	
L32	Clear	7.38	7.54	36.71	73.29	62.3	45.8	3.6	0.2
L34	McLelland	8.68	7.89	156.03	205.97	16.7	16.2	3.3	1.4
L35	Kearl	8.2	7.58	96.62	112.35	23.4	15.9	5.2	0.9
L37	Audet	8.52	7.84	158.07	224.70	22.1	23.2	6.0	< 0.1
L38	Johnson	8.68	7.83	181.78	278.73	70.2	29.1	23.3	< 0.1
L39	Unnamed	6.75		9.94		52.6		25.9	
L40	Unnamed	8.03		64.76		10.3		4.2	
L42	Unnamed	8.13		99.68		18.3		2.3	
L43	Unnamed	8.01		80.56		16.8		5.1	
L44	Unnamed	8.84		80.56		10.4		2.6	
L45	Unnamed	8.02		74.45		12.7		4.2	
L48	Unnamed	7.43		58		98		115.7	

Source: Data from D. Trew, Alberta Environmental Protection.

[a] After Erickson (1987), total alkalinity values of < 10 mg/L, 11 to 20 mg/L and 21 to 40 mg/L are considered indicative respectively of high.

respectively (Alsands 1981). Groundwater in these aquifers represent HCO_3-Na and HCO_3-Na-Ca-Mg hydrochemical facies.

4.5.1.3 McMurray Basal Aquifer

This aquifer is confined. It is represented by fine to coarse grained sand (0 to 40 m thick) deposited on top of the Upper Devonian sediments. Hackbarth and Nastasa (1978) indicates that the thickness of this aquifer in greater than 15 m near Bitumount. Hydraulic head within this aquifer varies from 4.5 to 61.5 m below ground surface. Groundwater quality tests for approximately 100 samples indicated the pH ranges from 7.4 to 8.5, TDS ranges from approximately 1700 to 4500 mg/L, chloride concentrations ranges from 246 to 1434 mg/L, and sodium ranges from 243 mg/L to 1477 mg/L (Alsands 1978). Based on the groundwater quality analysis, the groundwater in the is aquifer is brackish.

4.5.1.4 Methy Aquifer

The Methy Aquifer is confined and is represented by carbonate sediments of Middle Devonian Age. Groundwater quality tests for approximately 6 samples indicated the pH ranges from 6.8 to 8.3, TDS ranges from approximately 14 520 to 77 286 mg/L, chloride concentrations ranges from 6000 to 43 000 mg/L, and sodium ranges from 3600 mg/L to 27 300 mg/L (Alsands 1978). The groundwater chemistry in the Methy Aquifer and the McMurray Basal Aquifer are different, therefore there is no apparent hydraulic connection between these aquifers.

4.5.1.5 La Loche Aquifer

The La Loche Aquifer occurs immediately above the Precambrian basement. It is a confined aquifer with variable thickness and hydraulic properties. The hydraulic head for this aquifer is approximately 25 m below ground surface. This aquifer contains brine of the chloride-sodium type.

4.5.2 *Groundwater Flow*

Three zones of groundwater flow can be identified in the areas: shallow, intermediate and regional flow. The freshwater hydraulic head in the regional area is outlined in Figure 4.25.

4.5.2.1 Shallow

The shallow groundwater flow system in the surficial unconfined aquifer and the unconfined McMurray Aquifer is towards the west and the Athabasca River, mostly controlled by ground surface topography and local drainage pathways. The groundwater in the shallow system is likely recharged by precipitation and the groundwater quality should be relatively fresh.

4.5.2.2 Intermediate

Intermediate groundwater flow can be defined as groundwater movement in McMurray Basal which is towards the Athabasca River. This aquifer is confined and is recharged by the infiltration

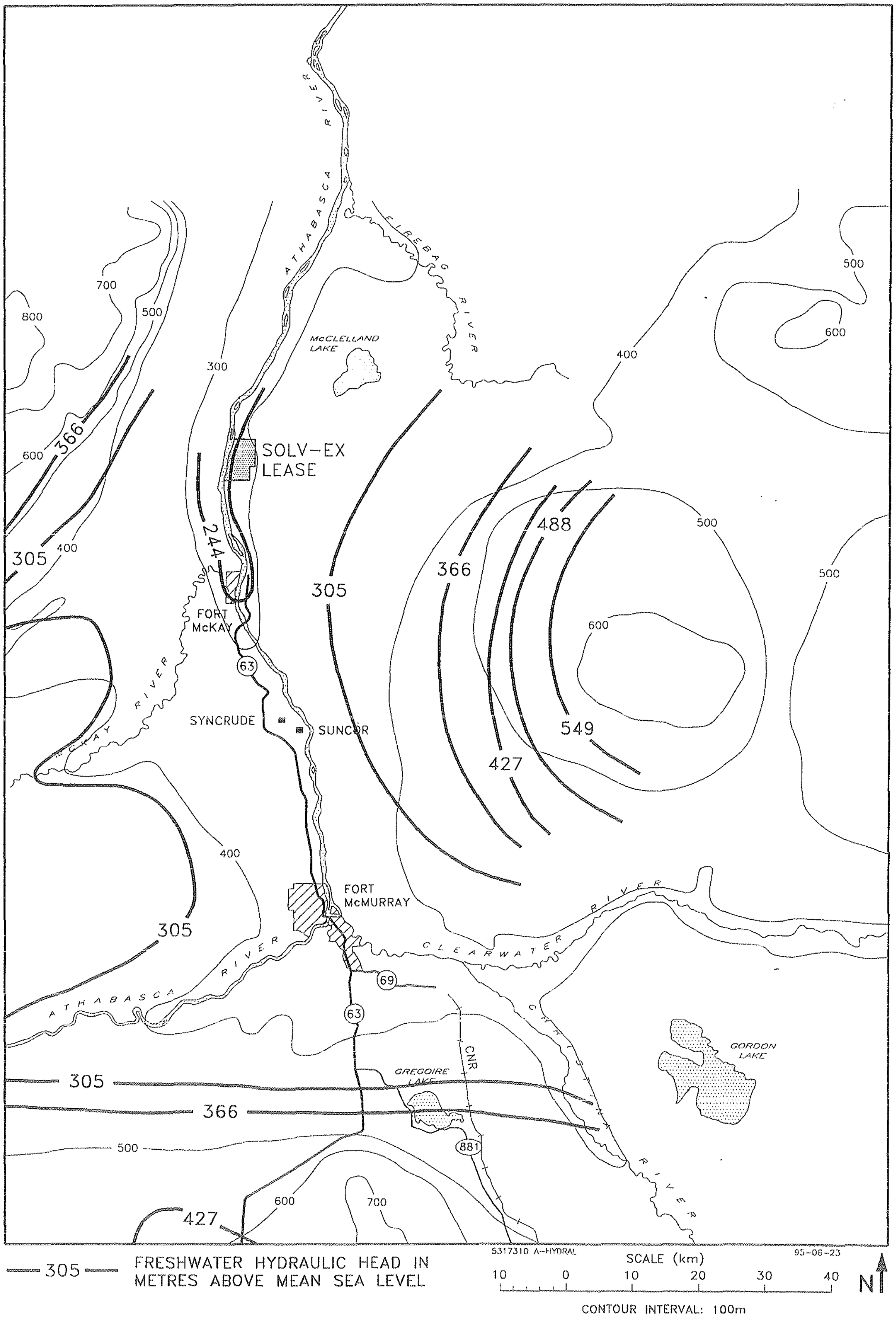


FIGURE 4.25 FRESHWATER HYDRAULIC HEAD

of precipitation northeast of the topographic highs located less than 10 km east and northeast of the Local Study Area.

4.5.2.3 Regional

Regional groundwater flow as represented by hydraulic heads in the Methy and La Loche aquifers in southwest and towards the Athabasca River. Both of these aquifers are confined character with recharge likely occurring 30 to 50 km from the study area.

4.5.2.4 Springs

No saline springs were encountered in areas to be developed during a field survey in June 1995.

4.5.2.5 Groundwater Usage

Drainage valleys in the Paleozoic strata could impact groundwater flow and groundwater usage of the area. The Paleozoic strata dips gently toward the southwest. The irregular configuration of the upper Devonian (pre-Cretaceous unconformity) is due to combination of subaerial erosion, resulting in the development of well-defined drainage system. In that section, the major valley system of the Paleozoic, three valley systems have been identify (Hackbarth and Nastasa 1978). Two of these valleys are located to the south of Fort McMurray and drain into the Athabasca River. The other valley is located approximately 100 km north of the of Bitumount trending through Townships 98 and 99, Range 10, and drains into the Bitumount. No groundwater usage was identified in the later valley, therefore the effects of mine depressurization activities should be negligible.

To identified groundwater usage in the vicinity of the Local Study Area, a water well survey of the area shown in Figure 4.26 was conducted using the well records at Alberta Environmental Protection. These records identified one domestic well in the area (Figure 4.26). The water well is completed at the 116 m depth and is drawing groundwater from the 55 m to 93 m depth. This water well will be abandoned, therefore effects of potential mine depressurization should be negligible.

Pump-test data of the McMurray Basal aquifer by Alsands (1981) indicate that if dewatering of this aquifer is required, depressurization of the Surficial and McMurray Basal aquifer(s) may affect the area within 0.5 km and 10 km, respectively from the Mine Area. The Alberta Environmental Protection water well records do not indicate any groundwater users within this area, therefore potential mine depressurization should have no impact on the groundwater resources in the area.

4.6 Vegetation

The Biophysical Cumulative Effects Study Area includes portions of the Athabasca River Valley and Undulating Sandy Plain Ecodistricts of the Mid-Boreal Mixedwood Ecoregion (Strong 1992). This Ecoregion is characterized by forest associations of white spruce, black spruce, jack pine, balsam fir, tamarack, aspen, balsam poplar and white birch. Although white spruce is the

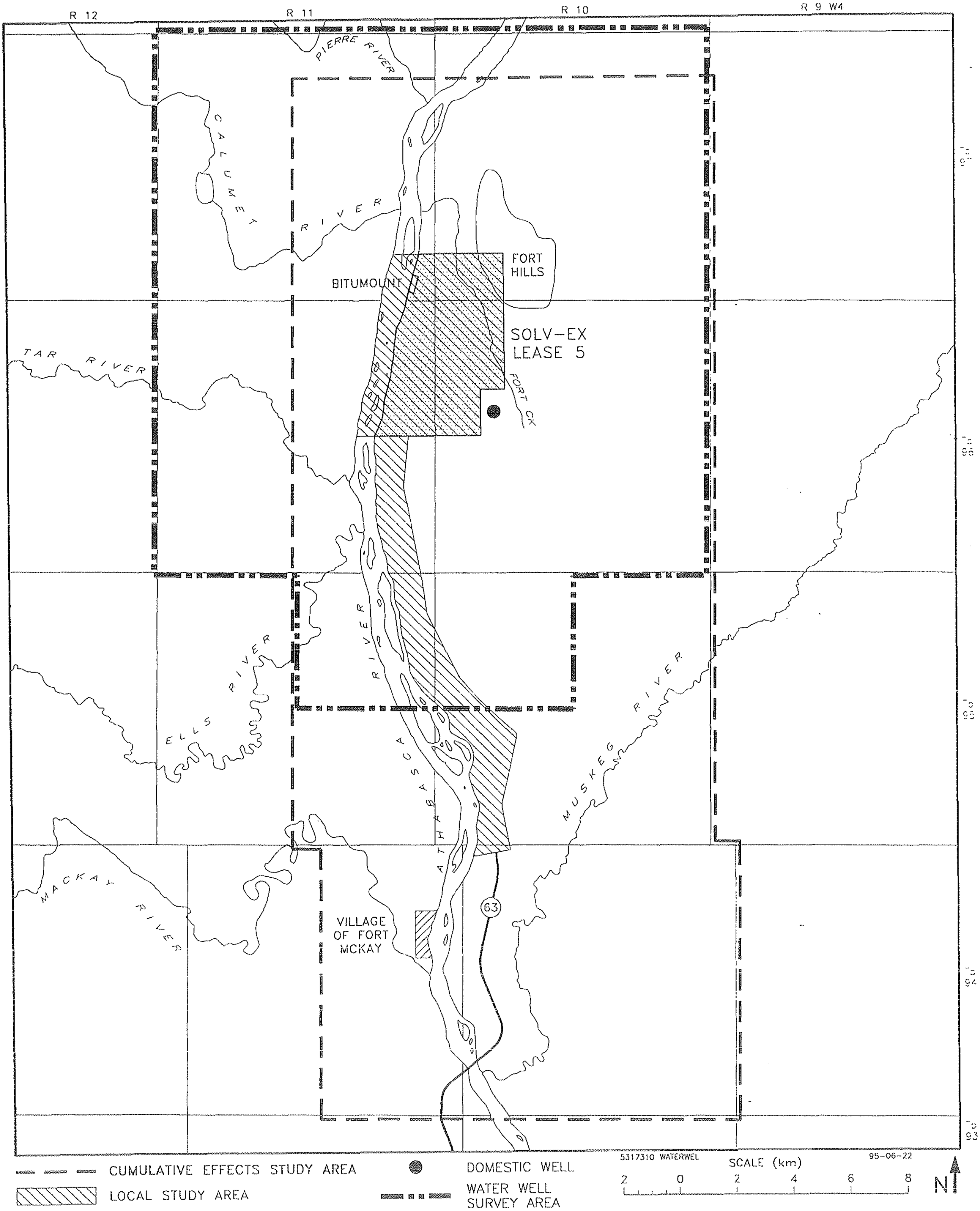


FIGURE 4.26 WATER WELL STUDY AREA

climax species on well-drained sites, disturbances such as forest fires keep the majority of these sites in various sub-climax stages. Aspen is abundant due to its ability to regenerate by vegetative means (e.g., suckering). Jack pine is dominant on sandy soil because of its tolerance to drought. Through the ability of its cones to open and release seed after being heated by fire, jack pine is capable of pioneering recently burned sites. Poorly-drained, low-lying areas support black spruce because of that species' ability to tolerate poor nutrient regimes and low soil/water oxygen availability.

Lowland areas with restricted drainage and cold soil environment provide conditions suitable for peat accumulations. These bogs and fens often do not support tree growth.

The overall appearance of the vegetation is a mosaic of types. The patterns are highly dynamic as a result of natural disturbance by fire and alterations in surface drainage (e.g., beaver dams). Post-fire successional patterns depend on fire intensity, frequency and behaviour. Other less evident controls on local vegetation patterns include disease and insect damage, windfall, permafrost and topography.

Several generally accepted successional trends have been recognized in the region. Vast upland areas are in the early stages of post-fire succession. The theoretical successional sequence for this type of site is that the post-fire vegetation community of primarily aspen will be replaced by white spruce possibly with some balsam fir (Stringer 1976). Succession in river valleys and lakeshores is thought to proceed from willow scrub and alder to balsam poplar bottomland forest and possibly to balsam poplar-white spruce mixedwood forest (Stringer 1976). Bog and fen succession is usually from fen-bog through open muskeg to bog forest as the site dries and then back through open muskeg to bog-fen as peatmoss accumulates with a concomitant rise in the water table (Jeglum 1968, Sjors 1961, Stringer 1976).

The occurrence of old-growth forests in the Local Study Area is limited. The frequency of fires and other disturbances such as flooding, variations in water tables, insects and diseases have created a forest mosaic of early to mid-successional types. There are some older stands of white spruce located adjacent to the Athabasca River with ages estimated between 110 to 150 years and there are some older black spruce types within the wetland areas with ages up to 110 years (Phase 3 forest inventory). Although these stands are old, they do not have the characteristics of old-growth forests. Old-growth may be defined as those forested areas where annual growth equals the annual losses or where mean annual increment of timber volume equals zero (B. Ward, Regional Director, Alberta Forest Service, pers. comm.). They can also be defined as those stands that are self-regenerating, having a specific structure that is maintained. This structure includes juvenile, mature, dying and decaying trees of the same species.

4.6.1 *Vegetation Types*

The vegetation classification for the Local Study Area is based on the system developed for the OSLO project (Silva 1990). Forest cover classification was determined through the interpretation of 1986 and 1989 aerial photography and Phase 3 Forest Cover classifications. Ground-truthing of the vegetation classification was conducted in June, 1995 to document current forest cover within the areas proposed for development. No substantial changes to the forest vegetation from the 1986 and 1989 photography were noted during this field inventory, nor from air photographs of the Solv-Ex Lease obtained in May, 1995. The vegetation communities were classified from the interpreted forest cover and an interpolation of the vegetation community typing developed by Silva (1990). Table 4.17 summarizes the vegetation community classification and communities are presented in Figure 4.27. Appendix III summarizes the plant species within the vegetation communities for the Local Study Area.

The vegetation communities within the Local Study Area are described in Table 4.18. The white spruce communities are the single largest vegetation type covering 45% of the area. The black spruce communities is second in areal coverage at 29%. All other community types cover between 7 and 6%. Areas disturbed by human activities account for 5% of the land area. These areas include: Highway 63 right-of-way, Bitumount airstrip, Bitumount Historic Site, gravel pits and a barge landing site. Areas affected by seismic lines and other narrow linear disturbance are not included in Table 4.18, however, these disturbances are estimated to occupy an area of 164 ha within the Local Study Area.

4.6.1.1 White Spruce Series

The community types in this series are located on upland sites adjacent to the Athabasca River. They are characterized by well-drained glaciofluvial deposits with a submesic to subhydric moisture regime and a mesotrophic to permesotrophic nutrient regime. Seepage discharge often determines the character of the vegetation and the potential productivity of the site.

Climax White Spruce Type

Stand age ranges to a maximum of approximately 150 years. This type represents the most successionally advanced climatic climax upland forest. In the absence of disturbance, this type will self-regenerate to maintain a climax forest of primarily white spruce, black spruce and balsam fir, with isolated clones of aspen and balsam poplar. This vegetation type is situated on prominent upland ridges and the banks of the Athabasca River. Mesic to subhydric moisture regimes and mesotrophic to permesotrophic nutrient regimes characterize this type.

In the mature state, the overstory consists of a mixture of tall, mature white spruce and some balsam fir in a closed canopy. Patches of aspen and balsam poplar may also be present. On drier sites, the understory consists of a complex of multi-layered, multi-aged spruce (white and black spruce) and scattered balsam fir. Cool temperatures promote undergrowth of alder, willow, buffaloberry, low bush cranberry and wild sarsaparilla. Ground cover is comprised of a thick mat of feathermosses in which trailing evergreen shrubs; bog cranberry, twinflower and herbs; dewberry and bunchberry are rooted. On moister soils, the overstory canopy is more open and the deciduous tree species are less abundant. Additional undergrowth includes peat moss mounds, knight's plume, horsetail, twisted stalk, coltsfoot, lungwort, wintergreen and clubmoss.

Table 4.17 Vegetation Community Classification.

Vegetation Types	Map Unit
White Spruce Series	
Climatic climax white spruce forest (moist and drier sites)	1a
Aspen forest (moist and drier sites)	1b
Aspen - jack pine forest (drier sites)	1c
Jack Pine Series	
Edaphic climax jack pine forest (dry sites)	2
Jack pine (drier sites with 3b and 1c)	n/a
Black Spruce Series	
Climatic climax black spruce forest (moist and very moist sites)	3a
Jack pine/aspen - black spruce forest (moist and drier sites)	3b1
Aspen/jack pine - black spruce forest (moist and drier sites)	3b2
Bog Types	
Blanket bog	4a
Slope bog	4b
Bowl bog	4c
Fen Type	
String fen (drainage fen)	5b
Anthropogenic Types	
Various (cutlines, corridors, gravel pits, etc.)	7
Riparian Types	
Streams and rivers	8

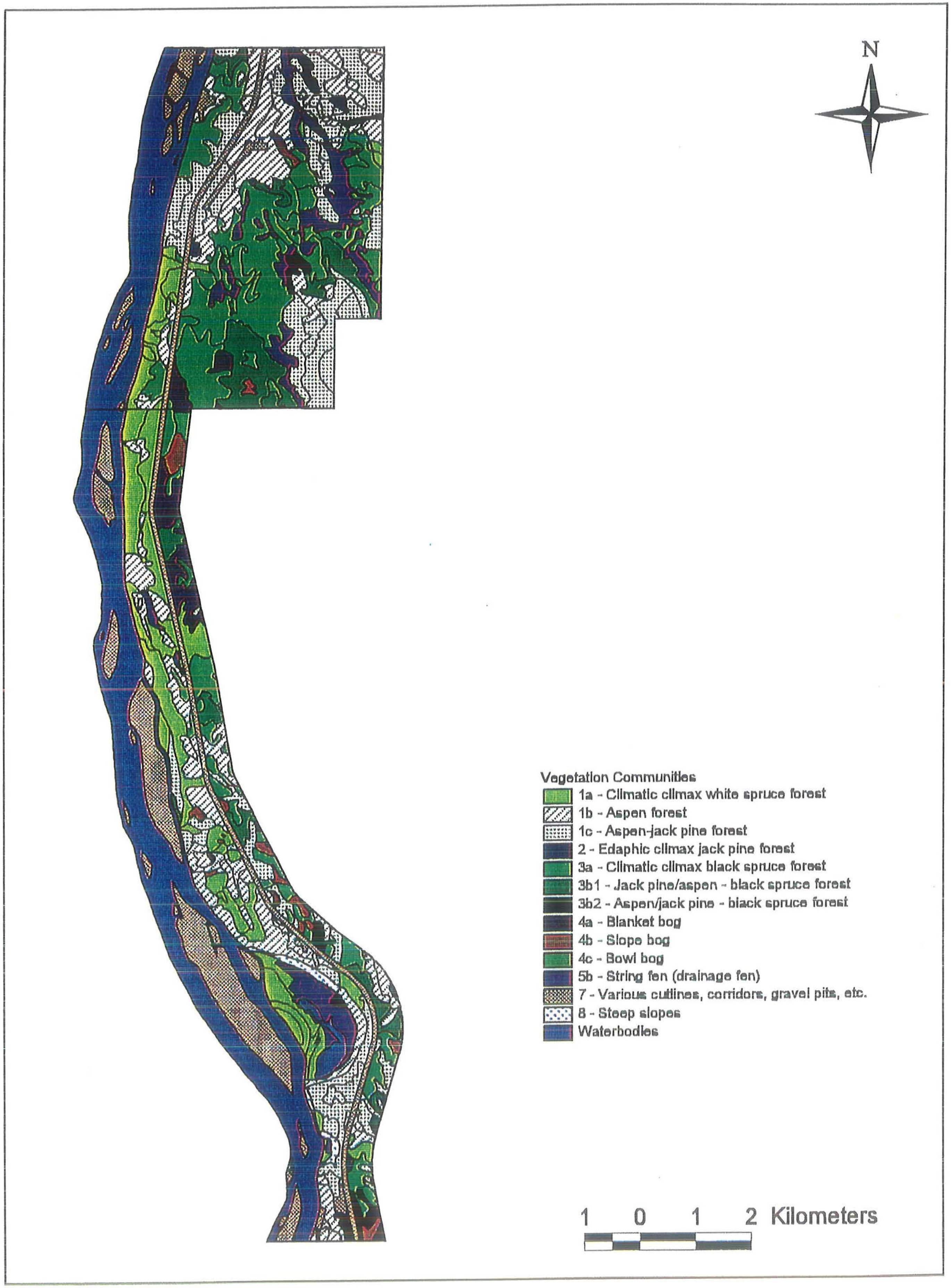


Figure 4.27 Vegetation Communities in the Local Study Area.

Table 4.18 Area of Vegetation Communities in the Local Study Area.

Vegetation Communities	Area (ha)[a]	Percent (%) of Area
White Spruce Series	2003	45
Jack Pine Series	248	6
Black Spruce Series	1283	29
Bog Types	313	7
Fen Types	304	7
Anthropogenic Types	274	6
Riparian Types	n/a	0
TOTAL	4425	100

[a] The area of cutlines and wellsites is not separated from the individual community types.

In the early successional stages, this forest type can either be a closed canopy (greater than 50%) or open canopy (less than 30%). Heights for early successional stands are under 12 m. The early successional stages result from disturbances such as scouring of the river banks during flooding or wild fire. Fluctuations in the water table also maintains some stands in early successional stage as White spruce trees expand and recede into the bog areas. As the type matures, canopy closure continues. At full maturity heights range from 18 to 30 m and canopy closure varies from 50% to 100%.

Aspen Type

This vegetation type is indicative of a mid-successional stage, which would lead to white spruce dominance if undisturbed for a minimum of 150 years. Aspen and balsam poplar are significant components and would remain well into the climax stage. The aspen type is located on prominent upland ridges and isolated upland hills. The moisture and nutrient regimes range from submesic to subhydric, and submesotrophic to permesotrophic, respectively.

An overstory of closed canopy aspen is exhibited with scattered white birch and jack pine on drier sites. An undergrowth of buffaloberry, alder, willow, and low bush cranberry exists with a ground cover of wild sarsaparilla, prickly rose, lily-of-the-valley, blueberry, kinnikinnick and hairy wild rye. Coniferous (white and black spruce) regeneration is significant but patchy. On moist sites, the overstory is similar but includes balsam poplar and the undergrowth includes additional species such as wild vetch, honeysuckle, twisted stalk and three-leaved Solomon's seal. Black spruce regeneration is significant.

Within the Local Study Area, the composition of the Aspen Forest type is composed primarily of closed canopy stands (between 50 to 100% canopy closure). Tree height varies from less than 6 m to maximum height of 30 m. Open canopy aspen types (less than 50% canopy closure) are generally tall tree communities (up to 30 m). Aspen types with heights less than 6 m are usually related to disturbances such as clearings. These types are commonly associated with white spruce with a percent composition of up to 40%.

Aspen-Jack Pine Type

This forest type is found on prominent upland ridges with subxeric to mesic moisture regimes and submesotrophic to mesotrophic nutrient regimes. They are considered mid to late-successional leading to a white or black spruce dominance. On extremely xeric sites, jack pine could become a dominant climax species.

The overstory consists of fire initiated patches of pure aspen and jack pine in association with occasional fire residuals of pine. Scattered white birch may also occur. Buffaloberry, prickly rose, kinnikinnick, bog cranberry, blueberry and dogbane are found under the pine overstory. Beneath the aspen overstory, alder, willow, low bush cranberry and numerous deciduous herbs and grasses occur.

Composition of aspen and jack pine varies between individual stands, however, canopy closure and tree height remain relatively consistent. Within the Local Study Area, these sites are dominated by the jack pine component, with aspen comprising no more than 50% of the total composition. Canopies are generally open (less than 50%) and heights are less than 12 m.

4.6.1.2 Jack Pine Series

The community types in this series are located on upland sites characterized by rapidly drained sandy gravel deltaic ridgeplains and aeolian sand dune complexes with xeric moisture regimes and nearly oligotrophic nutrient regimes. The harsh environment limits the regenerative opportunities for all tree species. However, jack pine is the most capable of surviving sustained drought and periodic forest fires.

Edaphic Climax Jack Pine Type

Prominent aeolian dunes, narrow sinuous ridges and beach forms, and glaciofluvial plains characterize sites where this vegetation type grows. The coarse soil texture allows free drainage and, therefore, the moisture regime is subxeric to submesic while the nutrient regime ranges from oligotrophic to submesotrophic. The direction of succession depends on the moisture status of the site, with dry sites tending towards jack pine dominance and moister sites tending towards black spruce or mixed white and black spruce dominance.

Jack pine forests may appear in two structures. The first is a dense stand of nearly pure, young jack pine with a sparse undergrowth of blueberry, fireweed, Labrador tea, snowberry, saskatoon, prickly rose and wild strawberry. Canopy closure on these sites is commonly between 71 and 100%. Tree heights are usually between 6 to 12 m. Where the canopy of jack pine is more open, alder or aspen are abundant as codominants.

The second form of the this jack pine type is a parkland of widely spaced, mature pine with an alternately clumped and open undergrowth of alder, buffaloberry, juniper, pincherry, blueberry, kinnikinnick, dogbane, lily-of-the-valley and hairy wild rye interspersed with patches of Cladina and Cladonia lichens and feathermosses. Plants that indicate extremely dry sites include lichen, dogbane and crowberry. Indicators of a more moist environment include Labrador tea, clubmoss and feathermoss. Canopy closure ranges from 30% to greater than 70%. Most mature stands have a canopy density of between 50 to 70%. Heights of mature jack pine are normally between 12 to 18 m although some stands achieve heights greater than 24 m.

Jack Pine-Aspen Type

The species inhabiting this type are described under the Aspen-Jack pine vegetation type in the white spruce series. The types are similar, but the extreme drought on the Jack pine-Aspen type influences succession. Aspen is unable to withstand extensive drought resulting in an overstory dominance of jack pine. These sites are usually pure stands of jack pine with open canopies (less than 50%) and heights less than 12 m.

4.6.1.3 Black Spruce Series

The community types in this series are situated on upland sites characterized by moderately well drained to imperfectly drained sites on slight depressions with slopes of 5 to 15%. The moisture and nutrient regimes range from mesic to subhygric and mesotrophic to permesotrophic respectively. Black spruce is more tolerant of poorly drained sites and poor nutrient regimes than other tree species and can establish on sites such as these without the additional stress of interspecific competition.

Climatic Climax Black Spruce Type

This vegetation type is typically located on flanks of upland ridges and across low rising hills. Sites are often located between lowland peat types and upland forests. Moisture regimes range from subhygric to hydric and nutrient regimes may be submesotrophic to permesotrophic.

Moist sites with a good nutrient status support an overstory of black spruce with an understory of multi-aged, multi-layered black spruce, which normally regenerates from advanced growth. Patches of aspen, balsam poplar and white birch also occur. The undergrowth is luxuriant consisting of alder, willow, Labrador tea, low bush cranberry, bog birch, shrubby cinquefoil, honeysuckle, bog cranberry, tiger lily, lungwort, grass of parnassus, marsh reed grass, hairy wild rye, bluegrass, feathermosses and peat moss. Sites with a poorer nutrient status include coltsfoot, horsetail and oak fern.

Wet sites possess a floristic composition similar to a productive blanket bog. Black spruce is dominant and often associated with tamarack and, occasionally, poplar, and white birch. The understory is characterized by layered black spruce, Labrador tea, cloudberry, horsetail, bog cranberry, and three-leaved Solomon's seal rooted in peat moss and feathermosses.

This vegetation community has canopy closures varying between 30 and 100% with most stands having less than 50% closure. Tree heights are commonly between 6 and 12 m. In some instances, heights can reach as much as 18 m.

Jack Pine/Aspen-Black Spruce Type and Aspen/Jack Pine-Black Spruce Types

These aspen/pine variants are found on upland ridge tops and slopes. Moisture and nutrient regimes range from submesic to mesic and submesotrophic to mesotrophic. These types are classified as mid to late successional and are expected to lead to a self-regenerating black spruce climax, or mixed spruce climax if a white spruce seed source is available.

These types consist of an overstory of jack pine and aspen, as well as some second growth of both species. Black spruce is prominent beneath the canopy. Moist sites support an undergrowth of alder, willow, cinquefoil, Labrador tea, bog cranberry, twinflower and bunchberry and a thin but continuous cover of feathermosses with patches of lichen beneath old pine. Drier sites support sporadic regeneration of aspen, jack pine and black spruce. Undergrowth includes buffaloberry, prickly rose, kinnikinnick, bog cranberry, twinflower, hairy wild rye, feathermosses and *Cladina* lichens.

These community types have tree canopy heights of less than 18 m with most heights less than 12 m. Canopy closure is usually open with less than 50% density.

4.6.1.4 Bog Types

The vegetation communities in this category are found on lowland sites. All types share a hydric moisture regime and oligotrophic nutrient status. These sites are often characterized by poor drainage and a significant depth of organic matter (peat). In most cases, these types are unable to support merchantable tree growth.

Blanket Bog

This bog type supports a cover of scattered, stunted black spruce accompanied by Labrador tea, bog birch and willow. The ground cover is simple, consisting mainly of cloudberry, bog cranberry, and three-leaved Solomon's seal. Microrelief creates some variability. Peat moss hummocks support patches of *Cladina* and *Cladonia* lichens while wet depressions support sedge, horsetail and cotton grass. Blanket bog communities are self-maintaining.

Slope Bog

Slope bogs are linear features often connecting areas of water impoundment such as blanket bogs and fens. The community is bordered by narrow bands of white spruce, black spruce, balsam poplar and white birch. Dense willow and bog birch are found along the poorly defined drainage ways. The undergrowth varies, being either bog or riparian in nature. Bog species include Labrador tea, cloudberry, bog cranberry, rice grass, sedges, peat moss and feathermosses. Riparian species include alder, dogwood, buckthorn, reed and bog muhly. Slope bog communities are self-maintaining.

Bowl Bogs

Bowl bogs are discrete features found in both uplands and lowlands. They vary widely in floristic character depending on site drainage and the adjacent vegetation. A seasonally fluctuating water table and progressive accumulation of mainly graminoid peat facilitates the gradual succession from a graminoid-sedge-leatherleaf - laurel minerotrophic meadow to a bog complement of black spruce, Labrador tea, bog birch, shrubby cinquefoil, bog cranberry, cloudberry, and peat moss and feathermosses which often form hummocks. The effect of seepage discharge, by increasing nutrient availability, is evident in tree growth superior to other bog types. Bowl bogs may succeed to a self-maintaining blanket bog or to a climatic climax black spruce forest.

4.6.1.5 Fen Types

Fen communities are located on lowland sites. They are invariably found in association with bogs. Fens are minerotrophic in nature because the majority of water influx is surface and shallow subsurface discharge from adjacent uplands and lowlands. Sites are very poorly drained resulting in a hydric moisture regime and have as oligotrophic to mesotrophic nutrient regime.

String Fen

String fens have a dynamic nature because of periodic drying and flooding. Aquatic mosses form a wet mat on the water surface which supports sedges, cotton grass, cordgrass and bog muhly. Bordering the drainageways are bog birch, alder, shrubby cinquefoil and, in some cases, tamarack and white birch.

Patterned Fen

Patterned fens typically exhibit a surface pattern of discrete to very prominent parallel ridges and troughs aligned perpendicular to the direction of water flow. Ridges support aquatic mosses, peat mosses, bog laurel, leatherleaf, bog rosemary, and scrub black spruce and tamarack. Troughs support mosses, sedges, cotton grass, pitcher plant, and sundew. Under very wet conditions, patterned fens are self-sustaining. Under drier conditions, they succeed to blanket bogs.

4.6.1.6 Aquatic Types

Aquatic communities are not well represented in the Local Study Area because of the lack of suitable conditions. They are commonly found in permanent ponds and standing waters in streams and lakes.

Aquatic species include yellow pond lily, pondweed, giant bur weed and duckweed. The littoral zone supports reed, cattail and rushes progressing to sedge, coltsfoot, calla lily, slough grass, tufted hair grass, cord grass and ericaceous shrubs. As open waters fill with vegetation, these types succeed from aquatic to emergent and, ultimately, to fen-bog or bog.

4.6.1.7 Anthropogenic Types

Cut-lines and wellsites are present throughout the Study Area. Moisture and nutrient regimes of these sites are similar to adjacent vegetation. Industrial activities cause a reversal of succession to a pioneer stage. Most activity occurs in winter on frozen ground; therefore, disturbance is confined to the ground surface leaving the root zone relatively intact. As a result, the potential for rapid recolonization of sites through vegetative reproduction is high especially for perennial grasses and herbs, and deciduous shrubs and trees.

Other activities that have disturbed the vegetation include: the Bitumount historic site, the Bitumount airstrip, gravel pits, utility and road corridors and barge landing sites. These sites have been subject to greater disturbance than the cutlines and wellsites, including the exposure and movement of mineral soil.

4.6.1.8 Riparian Types

Riparian types occur along streams and rivers, and usually reflect the character of the surrounding area. All types exhibit succession from water's edge to upland and, therefore, are typically early seral. Lowland sites support reed, cattail, calla lily, and sedges within the channel and bordering species include tall willow, alder, dogwood, buckthorn, white spruce, black spruce and poplars.

Upland sites support alder, dogwood, willow, bog birch, marsh reed grass, tufted hair grass, horsetail, shrubby cinquefoil, sedges, rushes and cord grass. Riparian communities are not self-maintaining. Without disturbance, they succeed to the climax stage of the surrounding vegetation.

4.6.2 *Rare and Unique Plant Species and Communities*

A number of rare plant species have been identified in the region (Packer and Bradley 1984, Cottonwood Consultants 1987). Table 4.19 lists the rare vascular plant species, their associated habitat and category of importance.

Hardy Associates (1978) Ltd. (1980) conducted a rare plant survey for the Alsands project area. Although they did not locate any plant species with a rare status, they did encounter and identify some species which are considered uncommon in the province. These species are also listed in Table 4.19.

In addition to rare and uncommon species, there are some species with specific habitats that may respond negatively to disturbance (J. Hrapko, curator of vascular plants, Provincial Museum, pers. comm.) such as three-toothed cinquefoil, which requires open sandy woods.

A rare plant inventory of the Solv-Ex Development Area was conducted in June of 1995. This inventory did not reveal the presence of any rare plants within the development areas or within the Athabasca River valley adjacent to the proposed mine (Alternative A). Alder-leaved buckthorn, an uncommon plant for Alberta, was located within the southeast edge of the tailings area and in area immediately south of the proposed plant site. This plant species was also located outside of the area that is proposed for disturbance. In all cases, there were numerous numbers of buckthorn spread throughout the moist shrubland habitat in which it was found.

Along the Athabasca River there are several locations with exposed calcareous rock. These cliff locations may provide habitat suitable for smooth woodsia. No disturbance will occur in these areas that will affect this habitat. Similarly, Isodore's Lake appears to be a saline oxbow of the Athabasca River which may provide habitat suitable for the saline tolerant plants noted in Table 4.19. This area will not be disturbed.

There are no unique plant communities within the Local Study Area.

4.6.3 *Forest Cover Types*

Forest cover mapping, to Phase 3 standards, was completed for the Local Study Area. The areal coverage of the forest cover types is listed in Table 4.20. Cover type polygons were classified to tree species composition, crown density and height. Each polygon includes all tree species with > 10% cover.

The most abundant forest type is the black spruce type, covering 939 ha (21%) of the Local Study Area. Aspen, the second most common cover type covers 762 ha (17%). White spruce dominated types occupy 472 ha (11%) of the Study Area. Other cover types with coverage greater than 5% of

Table 4.19 Rare or uncommon plants within the region.

Botanical Name	Common Name	Status[a]	Habitat
Carex oligosperma	few fruited sedge	P[b,c,d]	Wet meadows and bogs
Drosera anglica	oblong-leaved sundew	U	Swamps and bogs
Myrica gale	sweet gale	U	Swamps and thickets
Plantago maritima	seaside plantain	P[b,c]	Saline marshes
Polygala paucifolia	fringed milkwort	U[b],P[c,d]	Moist coniferous woods
Potomogeton obtusifolius	blunt-leaved pondweed	P[b,c,d]	Lakes and ponds
Rhamnus alnifolia	alder-leaved buckthorn	U	Moist shady woods
Sarracenia purpurea	pitcher plant	U	Peat bogs and muskeg
Scirpus rufus	red bulrush	P[b,c,d]	Saline marshes
Spartina pectinata	prairie cord grass	P[b,c,d]	Saline shores and marshes
Woodsia glabella	smooth woodsia	P[b,c,d]	Moist places on calcareous rock and shaded cliffs

[a] Status: (P) Provincially rare, (U) Uncommon

Sources:

[b] Alberta Energy/Forestry, Lands and Wildlife (1992).
[c] Cottonwood Consultants Ltd. (1987).
[d] Packer, J.G. and C.E. Bradley (1984).

Table 4.20 Area of Forest Cover Types in the Local Study Area.

Forest Cover Type	Area[a] (ha)	Percent of Area
White spruce	472	11
Jack pine	248	6
Black spruce	939	21
Black spruce/Jack pine	103	2
Jack pine/Black spruce	188	4
Jack pine/White spruce	18	<1
White spruce/Black spruce	12	<1
Aspen	762	17
Aspen/White spruce	241	5
Aspen/Jack pine	203	5
Jack pine/Aspen	199	5
White spruce/Aspen	90	2
Black spruce/Aspen	11	<1
Blanket Bog	257	6
Slope Bog	28	1
Shrub	21	<1
Bowl Bog	7	<1
Fen	304	7
Gravel pits	11	<1
Bitumount airstrip	12	<1
Road clearing	210	5
Barge landing site	4	<1
Bitumount historic site	10	<1
Steep slopes	34	1
Water	41	1
TOTAL AREA	4425	100

[a] The area of cutlines and wellsites is not separated from individual forest cover types.

the Local Study Area include fens, blanket bogs, jack pine, aspen/white spruce, aspen/jack pine, and road clearings. All other cover types were < 5% of the Local Study Area.

4.6.4 *Sensitivity to Air Emissions*

Individual plant species and vegetation associations can be sensitive to air contaminants especially if they are exposed over long periods of time. Air contaminants emitted from Solv-Ex operation include SO_2, NO_x, particulates, intermittent H_2S and hydrocarbons. Ozone could be formed as a result of photochemical reactions between emissions. The Fort McMurray Region is already under the influence of air emissions from existing industrial sources, including the Syncrude and Suncor Oil Sands Facilities.

Air emissions may cause direct injury to plant life in one or both of two ways:

- acute injury is the result of a high concentration of emissions over a short period of time (i.e., hours or days), and

- chronic injury is the result of relatively low concentrations of emissions emitted over a long period of time (i.e., months or years).

Symptoms of injury, however, may occur as a result of direct effects, indirect effects and/or secondary effects.

- Direct effects are produced when the plant absorbs gases or liquids containing contaminants (often referred to as dry and wet deposition). Plant life in western Canada is rarely injured from the direct uptake of wet deposition.

- Indirect effects are produced when the chemistry or biology of soil or waterbodies change the status of nutrients and toxic elements available to plants. The most common problems are a reduction in soil pH and the subsequent release of toxic aluminum ions.

- Secondary effects are produced when stress from emissions predisposes plant life to another type of injury such as frost damage or insect and disease damage.

Plants differ in their susceptibility to emissions damage. Those most tolerant or resistant to emissions also appear to be those which are more shade tolerant and likewise the most sensitive are those least shade tolerant (Malhotra and Blauel 1980). Often the most sensitive plants are the fastest growing species or individuals (Mattson and Witter 1990).

Lichens and mosses are considered the most sensitive plant groups to air emissions because they absorb all their nutrients from the air and rain water (Addison *et al.* 1986; Anderson and Treshow 1984; Baker 1989). Trees with long life cycles suffer particularly from long-term exposure because subtle effects can build up year after year to produce over-all harmful effects (Huttenen 1984).

Several agencies have identified target emission concentrations for SO_2 to protect sensitive ecosystems. The Province of Alberta and the Federal Government have established guidelines for emissions. The World Health Organization (1987) has established guidelines which are designed to protect sensitive vegetation in western Europe from SO_2 damage. The International Union of Forest Research Organizations (Huttenen 1984) has also established guidelines to protect even the most sensitive ecosystems. These guidelines are provided in Table 4.21. Relative sensitivities to air emissions of native plant species are presented in Appendix IV.

4.7 Wildlife Resources

Information on wildlife habitat and populations in the Biophysical Cumulated Effects Study Area (BCESA) and Local Study Areas (LSA) was compiled from the Alberta Oil Sands Environmental Research Program (AOSERP) studies (conducted between 1975 and 1984), more recent government maps and reports, and oil sand industry-based studies. The report prepared by Fort McKay on wildlife and fisheries resources and resource use (Fort McKay Environmental Services Ltd. 1995; Appendix V) provided background information for this section and locations of resources and use are illustrated in Figure 4.28. The BCESA and LSA are shown in Figure 1.3.

As noted in Section 4.0, the wildlife habitat map was prepared through airphoto interpretation and was ground-truthed in June 1995. There have been no substantial changes in habitat types in this area since at least the mid-1980's (based on our oldest airphoto coverage), and thus wildlife data collected for the AOSERP program (e.g., breeding birds, etc.) are still valid and relevant.

4.7.1 *Biophysical Cumulative Effects Study Area (BCESA)*

4.7.1.1 Important Wildlife Habitat

Ungulate Habitat

Important regional habitat for moose occurs in the BCESA. This includes the Fort Hills and the Calumet Plains (on the west side of the Athabasca River) (D.A. Westworth and Associates Ltd. 1990) and the Athabasca River and the Muskeg River (Alberta Land Inventory 1973, Alberta Fish and Wildlife 1988, D.A. Westworth and Associates Ltd. 1990). A number of salt licks have been identified in the BCESA by Fort McKay Environmental Services (1995; Appendix VIII).

Moose undertake seasonal migrations or local movements that can result in seasonal increases in density in favorable areas, and, conversely, in decreases in density in seasonally unsuitable habitat. On the east side of the Athabasca River, Hauge and Keith (1981) and Knapik and Westworth (1982) documented long-range movements (> 20 km) between winter ranges near the Fort Hills and the Athabasca River and summer ranges in the Muskeg Mountain area, and shorter range movements averaging 6 km between winter and summer ranges (some completely within the BCESA). The Athabasca River (including the mouth of the Muskeg River) is classified as important winter range for ungulates (ALI 1973; Figure 4.29). On the west side of the river, the movement of moose from the uplands to the Athabasca and MacKay rivers has been well documented (Pauls 1982, 1984, 1987; Penner 1976; Westworth 1979*a*, 1980). Movements

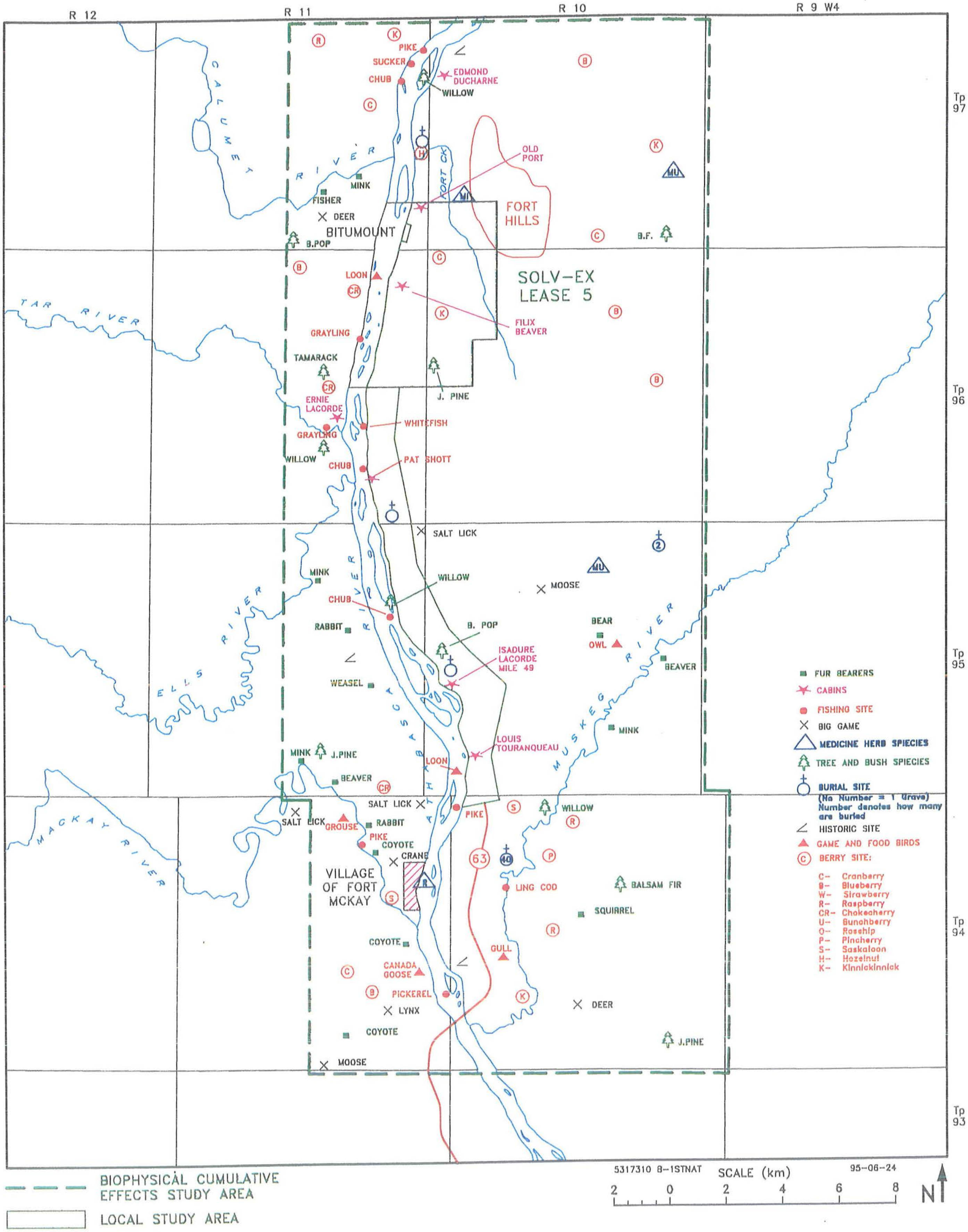


FIGURE 4.28 LOCATIONS OF FIRST NATIONS RESOURCE AND TRADITIONAL USES

Table 4.21 Guidelines for SO_2 Concentrations that are recommended to prevent injury to vegetation.

Duration	Alberta Guidelines and Federal Desirable Objectives	Federal Acceptable Objectives	IUFRO Objectives (forests under good growing conditions)	WHO Objectives (vegetation)
Annual	0.01 ppm	0.01 ppm	0.019 ppm[(a)]	0.011 ppm
Daily	0.06 ppm	0.12 ppm	0.038 ppm[(b)]	0.038 ppm
Hourly	0.17 ppm	0.34 ppm	0.05 ppm[(c)]	n/a

(a) Maximum average concentration
(b) Not to be exceeded more than 12 times in 6 months
(c) 97.5% of the 30 min. average growing season values < 0.056 ppm

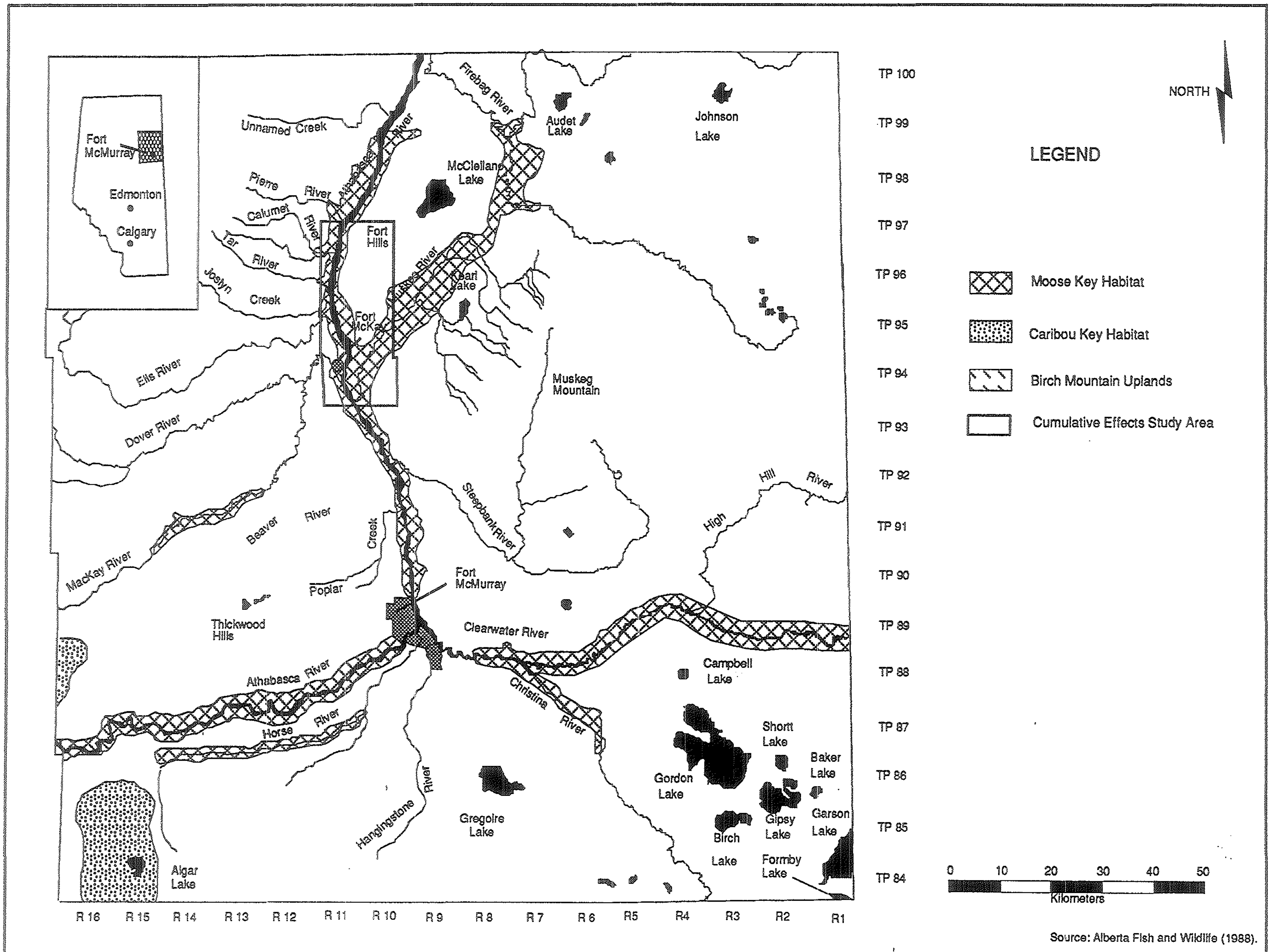


Figure 4.29 Key Ungulate Habitat in the BCESA.

usually occur in December to January, although this depends on snow conditions each year (Hauge and Keith 1981).

Bird Habitat

The Athabasca River, and McClelland and Kearl lakes provide important habitat for birds within or in the vicinity of the BCESA.

- The Athabasca River valley is a significant landmark for migrating waterbirds. Sandbars in the Athabasca River are common roosting sites for gulls. Peak migration times occur in May and September through October (Yonge and Christiansen 1979). 1988 studies along the Athabasca River within the BCESA noted densities of 0.3 birds/km^2 for diving ducks and dabbling ducks, 0.4 birds/km^2 for shorebirds and 0.1 birds/km^2 or less for all other groups (i.e., gulls, grebes, coots, geese, swans, herons, cranes, cormorants and pelicans) (R.L. & L. 1989). The banks of the Athabasca River also provide nesting escarpments for hawks and eagles (Syncrude Canada Ltd. 1978).

  Important lakes for waterfowl staging are Kearl (locally important) and McClelland (regionally important), which are both located east of the BCESA (Hennan *et al.* 1977, Posten *et al.* 1990; locations shown in Figure 4.29). The Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan (1994) notes that McClelland Lake is considered to be the best developed wetland in the boreal forest, and is one of the largest in the province. It consists of a rich fen containing well-developed patterns of springs and pools. Although the wetland and lake are not considered to be outstanding habitat for furbearers and ungulates, nor good breeding areas for waterfowl, the lake itself comprises the good spring/fall staging area for migrating waterfowl.

4.7.1.2 Wildlife Populations

This discussion on wildlife populations in the BCESA focuses on species of economic, recreational and political importance in the Fort McMurray region; i.e., ungulates, furbearers, carnivores, waterbirds, raptors, upland game birds, and rare, endangered or threatened species. Scientific names of bird and mammal species discussed in this text are listed in Appendix VI.

Ungulates

Moose is the most abundant ungulate in the region, while white-tailed and mule deer occur at very low densities.

Moose surveys have been conducted in the Athabasca Oils Sands Region from the early 1970's to the present. Based on these surveys, moose densities are comparable to those reported for other parts of northeastern Alberta, and relatively low compared to densities reported for central and northwestern Alberta. Telfer (1984) suggests that boreal forest and coniferous/deciduous transition ranges should support average regional moose densities of 0.1 and 0.3 moose/km^2, while excellent ranges, such as alluvial and riparian habitats of the Peace-Athabasca Delta should support 0.4 to 1 moose/km^2. Surveys on the east side of the Athabasca River and 17 km southeast of the Solv-Ex lease in 1985-86 showed densities of 0.11 moose/km^2 in December and 0.4 to 0.7 moose/km^2 in February (Salter *et al.* 1986, Eccles and Duncan 1988). Moose densities in the vicinity of the Solv-Ex lease in March 1995 were extremely low at 0.01 moose/km^2 (see Appendix VII).

These low densities could be the result of predation by wolves and hunting by local hunters.

- Hauge and Keith (1981) identified increased hunting pressure as a major contributor to a local decline in the Fort Hills moose population after the completion of the bridge across the Athabasca River and an access road to the Alsands site.

- They also estimated annual mortality rates of 0.73 for calves and 0.23 to 0.25 for yearlings/adults in the AOSERP area, with an estimated 29% of calf losses and 23 to 24% of yearling/adult losses resulting from wolf predation. Wolves killed disproportionately more young, old (>11.5 years), and probably debilitated moose, as well as more female calves and adult bulls. Fuller and Keith (1980*b*) estimated the Muskeg wolf pack, whose territory encompasses the BCESA, annually consumed about 15% of the yearling and adult moose within their range, which is close to the estimated recruitment of moose in the region of 19 to 30% (Hauge and Keith 1981).

Although **deer** have been observed as far north as the Alberta-Northwest Territories border, the BCESA is considered near the edge of these species' northern range. White-tailed and mule deer have been recorded in low numbers in the region, however, deep, crusted snow and severe weather can cause high annual mortality in deer populations. Deer winter along the Athabasca River and two sets of tracks were observed along the Fort Chipewyan winter road during the March 1995 winter track inventory of the Solv-Ex LSA.

Barrenland and woodland caribou have been seen in the BCESA historically (Fort McKay Environmental Services, 1995; Appendix VIII).

Terrestrial Furbearers and Carnivores

The most abundant large furbearers and carnivores in the BCESA are: coyote, timber wolf, black bear and lynx (Penner 1976, Westworth 1979). Fort McKay Environmental Services (1995; Appendix V) note that traditionally, the following furbearers are produced from the BCESA: wolf, coyote, fox, weasel (three species), wolverine and fisher (not prevalent), marten, otter, mink, beaver, squirrel, muskrat, lynx, black bear, and rabbit (fur and nest).

- Penner (1976) considered **coyotes** to be the most abundant large carnivore in the region, found in all habitat types, and its densities fall within the range of densities reported for this species in northern Alberta and the Northwest Territories. Track surveys conducted in the Syncrude lease area showed coyote tracks at densities of 0.29 tracks/km. Coyotes prefer semi-open habitat with stands of deciduous trees, and rarely occur in densely forested regions (Banfield 1974, Boyd 1977).

- The **timber wolf** in the BCESA, was studied through radio-collaring by Fuller and Keith (1980*b*) in 1977-78 and the winter density of wolves was estimated at 0.66 animal/100 km^2. Densities elsewhere in North America have varied from 8.33 and 0.19/100 km^2 (Mech 1970, Fuller and Keith 1980*a*). They may cover 250 to 650 km^2 (Banfield 1974). The size of home ranges of wolves vary seasonally, increasing in area in winter (Fuller and Keith 1980*b*).

  Wolf abundance and distribution is determined more by prey abundance than by habitat type.

  Studies in the region show that wolves concentrate their activities in open and disturbed habitats, although they are more commonly associated with forest habitat (Fuller and Keith 1980*b*). Penner (1976) noted that wolf movements are concentrated along rivers and in areas of disturbed snow cover, such as snowmobile trails, snowshoe trails, cutlines and roads.

- The status of **black bear** in the region has been studied. Fuller and Keith (*in* Penner *et al.* 1980) estimated densities of 2.0 to 4.0 km^2/bear in the Fort Hills area, while Young (1978) estimated a density of bears of 4.0 to 5.6 km^2/bear in the region (based on the relative abundance of cover types and densities within similar cover types near Cold Lake). These estimates represent relatively high densities of black bears in comparison to other areas of the boreal forest (Penner *et al.* 1980).

  Bears prefer a mosaic of habitats where food and cover are in close proximity. Habitat use appears to be related to the seasonal availability of food and protection cover from spring to fall, and to the availability of suitable denning sites from late fall through winter.

- **Lynx** populations follow the approximately 10 year population cycle of the snowshoe hare (Keith 1963) and the distribution of lynx is dependent on habitat preferences of the hare. The Study Area supports habitat of primarily moderate quality for hare, and therefore, for lynx.

The most common **small terrestrial furbearer** in the BCESA is the red squirrel followed by snowshoe hare (Penner 1976, Westworth 1979*b*). Other terrestrial furbearers trapped in the area include: weasel, fisher, marten and fox (red and cross) (Table 4.29). Recent fur harvest return data (1981-91) in the vicinity of the LSA are summarized in Section 4.9.3. Fort McKay Environmental Services (1995; Appendix V) notes that there may be an increase in fisher in the BCESA in the next few years due to displacement from heavily logged areas in the vicinity of the regional study area.

Aquatic Furbearers

Beaver is the most abundant aquatic furbearer in the BCESA, and low densities of muskrat, mink and river otter are encountered.

- **Beaver** densities along the Muskeg River to the south of the LSA were 0.4 lodges/km and within the large AOSERP region were 0.32 lodges/km (Gilbert 1978 *in* Salter and Duncan 1986). Favourable habitat for beaver in North America support 0.4 to 0.8 colonies/km^2 (Allen 1983).

- The region supports few lakes/wetlands that are suitable for **muskrat**. Excellent quality habitat in Alberta supports in excess of 40 muskrat houses/km^2 (Todd 1978).

- **Mink** densities are relatively high in the region (Gilbert *et al.* 1979, Green 1983, Knapik and Westworth 1982, Penner 1976, Searing 1979).

- **River otter** occur in low numbers throughout the region (Gilbert *et al.* 1979, Harvey 1979, Penner 1976, Searing 1979, Todd 1978). Boyd (1977 in Searing 1979) in an analysis of Alberta trapping records felt that river otters are present in low densities throughout their range, but were comparatively more abundant in northeastern Alberta.

Other Mammals

The **snowshoe hare** is a staple prey species for coyote and lynx, and affects the population cycles of these two predators (Knapik and Westworth 1982).

The **deer mouse**, **red-backed vole** and **meadow vole** are the most abundant species of mice and voles, concentrating in the forest and shrub-dominated habitats, with **meadow jumping mouse** and **heather vole** occurring in much lower numbers (Westworth and Skinner 1980, Westworth 1979*b*). Five species of shrews are expected to occur within the Syncrude area: **masked, pygmy, wandering**, **water** and **Arctic shrew** (Westworth 1979*b*).

Four species of bats (little brown bat, northern long-eared bat, big brown bat, and hoary bat), woodchuck, northern flying squirrel and least chipmunk also occur in the region (Smith 1993).

Although some of these species may be relatively abundant in the Study Area, none are of particular economic or ecological significance.

Waterbirds

The Peace-Athabasca Delta, a major staging, breeding and moulting area for waterbirds, lies 170 km north of the BCESA (Bellrose 1976, Hennan 1972, Young and Weber 1985). The paths of four migratory flyways, the Pacific, Central, Mississippi and Atlantic flyways, converge in the Fort McMurray area. The oil sands region is considered of general importance to staging fall migrants (e.g., McClelland and Kearl Lakes; Section 4.7.1.1) and of lesser importance for the stop-over of spring migrants (Hennan and Munson 1979, Schick and Ambrock 1974), except for several local lakes and the Athabasca River which were used during spring break-up.

The main migrant waterbird groups in the region are diving ducks, dabbling ducks, American coot and gulls, although low numbers of migrant shorebirds, grebes, loons, swans and geese have been recorded (McLaren and McLaren 1985, McLaren and Smith 1985, Sharp *et al.* 1975, Young 1985). Fort McKay Environmental Services (1995) identified the following local waterbird groups: geese, ducks, loons, pelicans, swans, cranes and gulls (Appendix VIII).

Extensive surveys have been conducted in the oil sands area to document the extent of waterfowl production (Hennan and Munson 1979, McLaren and Smith 1985, Schick and Ambrock 1974). Waterfowl production is limited in the region, with the exception of four lakes, Algar, Gordon, Saline and Horseshoe, where mean density of breeding pairs and broods are comparable to the densities associated with the prairie potholes (D.A. Westworth and Associates 1990, Hennan and Munson 1979, R L & L 1989, Schick and Ambrock 1974). Most other wetlands in the region are characterized by low fertility and sparse vegetation, which create poor availability of food, nesting cover and brood cover (Schick and Ambrock 1974).

The BCESA does not support important waterfowl migrant stop-over or production sites.

Other Birds

Twenty-two species of raptors are known to occur as migrants, seasonal residents, or permanent residents in the region, including 1 osprey, 2 eagles, 9 hawks, 3 falcons and 7 owls (Appendix II). Habitat use by these species is broad and varied, although generally, they prefer forest and forest edge habitats. Diets are comprised of a wide variety of small mammals (e.g., snowshoe hare, mice, voles, lemmings, shrews), but will also include birds, insects, snakes, frogs and carrion depending on the relative availability of an species-specific preference for these food items.

Upland game birds in the region include three year-round resident species of grouse (i.e., spruce, ruffed and sharp-tailed grouse), and one winter resident that breeds in the Arctic (i.e., willow ptarmigan) (Fort McKay Environmental Services 1995; Appendix V). Spruce and ruffed grouse are common, sharp-tailed grouse are uncommon and ptarmigan numbers are unknown (Francis and Lumbis 1979).

Spruce grouse prefer coniferous-dominated forest for much of the year. Numbers of observations ranged from a high of 0.46 individuals/km of transect in young mixedwood forest, to a low of 0.03 individuals/km in river riparian habitat (Francis and Lumbis 1979).

Ruffed grouse prefer deciduous or mixedwood forests with dense shrub understories (Francis and Lumbis 1979). Numbers of observations of ruffed grouse in the region ranged from 0.46 individuals/km of transect in tall bottomland willow habitats and 0.32 individuals/km in aspen forest, to lows of 0.02 individuals/km in both aspen-jack pine and young black spruce (Francis and Lumbis 1979). The ruffed grouse probably occurs throughout the Study Area in densities similar to those existing throughout the region. Areas of relatively young aspen and fairly dense undergrowth combined with deadfall, provide good ruffed grouse habitat. Based on habitat evaluation studies conducted in summer 1992 (Smith *et al.* 1992), only two habitat types provide a good year-round habitat for ruffed grouse, aspen-white spruce and white spruce dominated mixedwood. Both habitats provide an abundant shrub and berry producers, and good deciduous tree cover. Moderate quality habitat is provided by deciduous, aspen dominated mixedwood's and closed black spruce habitat, other habitats provide limited value.

Willow ptarmigan reach the southern limit of their normal wintering range near Fort McMurray. In winter, this species has been observed within all habitats that have a willow component (e.g., fen and treed muskeg), except black spruce (Francis and Lumbis 1979, RRCS 1972). They also prefer trembling aspen and riparian habitats.

Rare, Endangered or Threatened Species

A list of the possible rare, endangered, or threatened wildlife species that could occur in the region is given in Table 4.22.

Five bird species, important in Alberta because of their special status, are the whooping crane, peregrine falcon, white pelican, great grey owl and short-eared owl.

- The **whooping crane** is listed as an endangered species by both COSEWIC (1995) and under the Alberta Wildlife Act, and as a Red species by the Alberta Fish and Wildlife (1991). The whooping crane nests in and near Wood Buffalo National Park and migrates along the border between Alberta and Saskatchewan. Radio-tracking by the Canadian Wildlife Service has confirmed that the migration route of this species passes through the Fort McMurray area (E. Kuyt, Canadian Wildlife Service, pers. comm.).

- The **peregrine falcon**, also an endangered species (COSEWIC 1995, Alberta Wildlife Act) and Red species, is known to nest in the northern part of the AOSERP area, a small stable population breeds in the Fort Chipewyn-Lake Athabasca region (Munson *et al.* 1980). Historic nest sites, active in the 1950-60's, occurred in the area of Brule rapids on the Athabasca River west of Fort McMurray (D. Moore, Canadian Wildlife Service, pers. comm.). The Athabasca River valley may be an important migration corridor for this species (Francis and Lumbis 1979).

- From 1976 to 1986, the **American white pelican** was listed as a threatened species by COSEWIC. The populations of this species have been increasing and its name was de-listed in 1987. While the number of breeding birds across Canada may be increasing, however, the number of active colonies in Alberta is decreasing. For this reason, the white pelican is still regarded as an endangered animal in Alberta (S. Brechtel, Alberta Fish and Wildlife, pers. comm.) and is on the Red list. In 1987, a pelican rookery of 20 nests was located on Birch Lake in the Birch Mountains, and 135 nests on Namur Lake (Stepney 1987 of Alberta Fish and Wildlife Division *in* D.A. Westworth and Associates 1990). A small flock of pelican bred at Big Island Lake located 20 km northeast of Namur Lake. Foraging activity can extend up to a 70 km radius of the rookery (Beaver and Ballantyne 1979, Munson *et al.* 1980). The BCESA lies about 60 km east of Namur Lake, and is located on the fringe of pelican forge ranges.

Table 4.22 Potential Rare, Threatened or Endangered Species which could occur in the BCESA.

Species	**COSEWIC[a] (1995)**	**Alberta Fish and Wildlife (1991)[b]**	**Alberta Wildlife Act**
Birds:			
Whooping Crane	Endangered (1978)	Red List	Endangered
Peregrine Falcon	Endangered (1978)	Red List	Endangered
American White Pelican	De-listed (1987)	Red List	Endangered
Great Grey Owl	Vulnerable (1979)	Blue List	N/A
Short-eared Owl	Vulnerable (1994)	Status Undetermined	N/A
Mammals:			
Wolverine	Vulnerable (1989)	Blue List	N/A
Canada Lynx	Not Listed	Blue List	N/A
River Otter	Not Listed	Blue List	N/A

(a) The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, sub-species and separate populations in Canada. All native amphibians, reptiles, birds and mammals are included. The definition of categories related to wildlife are:

- Endangered - A species threatened with imminent extinction or extirpation throughout all or a significant portion of its Canadian range.

- Threatened - A species likely to become endangered in Canada if factors affecting its vulnerability are not reversed.

- Vulnerable - A species particularly at risk because of low or declining number, small range or for some other reason, but not a threatened species.

(b) Species are identified by Alberta Fish and Wildlife (1991) into color categories. The two categories concerning Rare, Threatened or Endangered species are:

- Red - These species are in serious trouble. Their populations are nonviable or at immediate risk of declining to nonviable levels in Alberta. They have, or will be considered, for designation as Endangered Species in Alberta.
- Blue - These species are also at risk, but the threats they face are less immediate. They are particularly vulnerable to non-cyclical declines in population or habitat, or to reductions in provincial distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to clearly define their status, have also been placed in this category.

- The **great grey owl** is classified as vulnerable by COSEWIC (1995) and is on the Blue list of Alberta Fish and Wildlife (1991). This species is considered an uncommon resident in the AOSERP region (Francis and Lumbis 1980). This species prefers boreal forest, either coniferous or deciduous; spruce-tamarack bogs (Godfrey 1986). Although found throughout the region it is considered uncommon (Francis and Lumbis 1979).

- The **short-eared owl** was listed as vulnerable by COSEWIC (1995) in 1994. It prefers open grassy or shrub habitats and marshy areas (Godfrey 1986).

Three special status mammals could occur in the BCESA: the wolverine, Canada lynx and river otter.

- The **wolverine** is classified on the Blue list by the Alberta Fish and Wildlife Division (Alberta Fish and Wildlife 1991) and as vulnerable by COSEWIC (1995). The density of wolverine in the region is low, but equivalent to the densities found in other parts of northern Alberta or the Northwest Territories (Penner 1976). Westworth (1979*b*) estimated wolverine densities in the area at 0.08 animals/100 km^2. The wolverine exhibits diverse habitat and food preferences, although it is usually restricted to remote, heavily forested areas. It has large territories extending 200 to 500 km^2 (Westworth 1979*b*).

- The **Canada lynx** and **river otter** are on the Blue List (Alberta Fish and Wildlife 1991) and not listed by COSEWIC.

4.7.2 *Local Study Area*

4.7.2.1 Terrestrial Habitat Types

Wildlife Key Area Maps illustrate critical areas for wintering moose within the LSA, along the Muskeg and Athabasca rivers (Alberta Fish and Wildlife 1988; Figure 4.29). No critical areas for waterfowl, other colonial nesters, upland game birds, or raptors have been identified.

The Local Study Area covers approximately 4550 ha. Eleven terrestrial habitat types were identified and mapped (Figure 4.30), and their areas are summarized in Table 4.23. The most abundant habitat types in the LSA in decreasing order of abundance, are: open black spruce (19%), aspen (17%), white spruce (11%) and deciduous dominated mixedwood (10%). The remaining habitat types occupy < 7% of the LSA. The habitats in the LSA are common to a large portion of the boreal forest in northern Alberta. Description of the more important habitats for wildlife in the LSA has been based on existing regional studies.

Open Black Spruce

Open Black Spruce develops on poorly drained areas and supports a sparsely treed community of open and clumped black spruce, with the occasional occurrence of deciduous trees and tamarack.

Table 4.23 Area of Forest Cover and Habitat Types in the Local Study Area.

Forest Cover Type	Area (ha)[(a)]	Habitat Type	Habitat Unit	Area (ha)	Percent of Area
White spruce	472	White spruce	WS	472	11
Jack pine	248	Jack pine	JP	248	6
Black spruce	939	Open black spruce	OBS	837	19
		Closed black spruce	CBS	102	2
Black spruce/Jack pine	103	Mixed Coniferous	MC	321	7
Jack pine/Black spruce	188				
Jack pine/White spruce	18				
White spruce/Black spruce	12				
Aspen	762	Aspen	A	762	17
Aspen/White spruce	241	Deciduous dominated mixedwood	DDM	444	10
Aspen/Jack pine	203				
Jack pine/Aspen	199	Coniferous dominated mixedwood	CDM	300	7
White spruce/Aspen	90				
Black spruce/Aspen	11				
Blanket Bog	257	Shrub	S	306	7
Slope Bog	28				
Shrub	21				
Bowl Bog	7	Sedge meadow	SM	311	7
Fen	304				
Gravel pits	11	Disturbed	D	242	6
Bitumount airstrip	12				
Road clearing	20				
Barge landing site	4				
Bitumount historic site	2				
Steep slopes	34			34	
Water	41	Wetlands	W	41	1
TOTAL	4425			4425	100

(a) Area of cutlines and wellsites have not been separated from forest cover types.

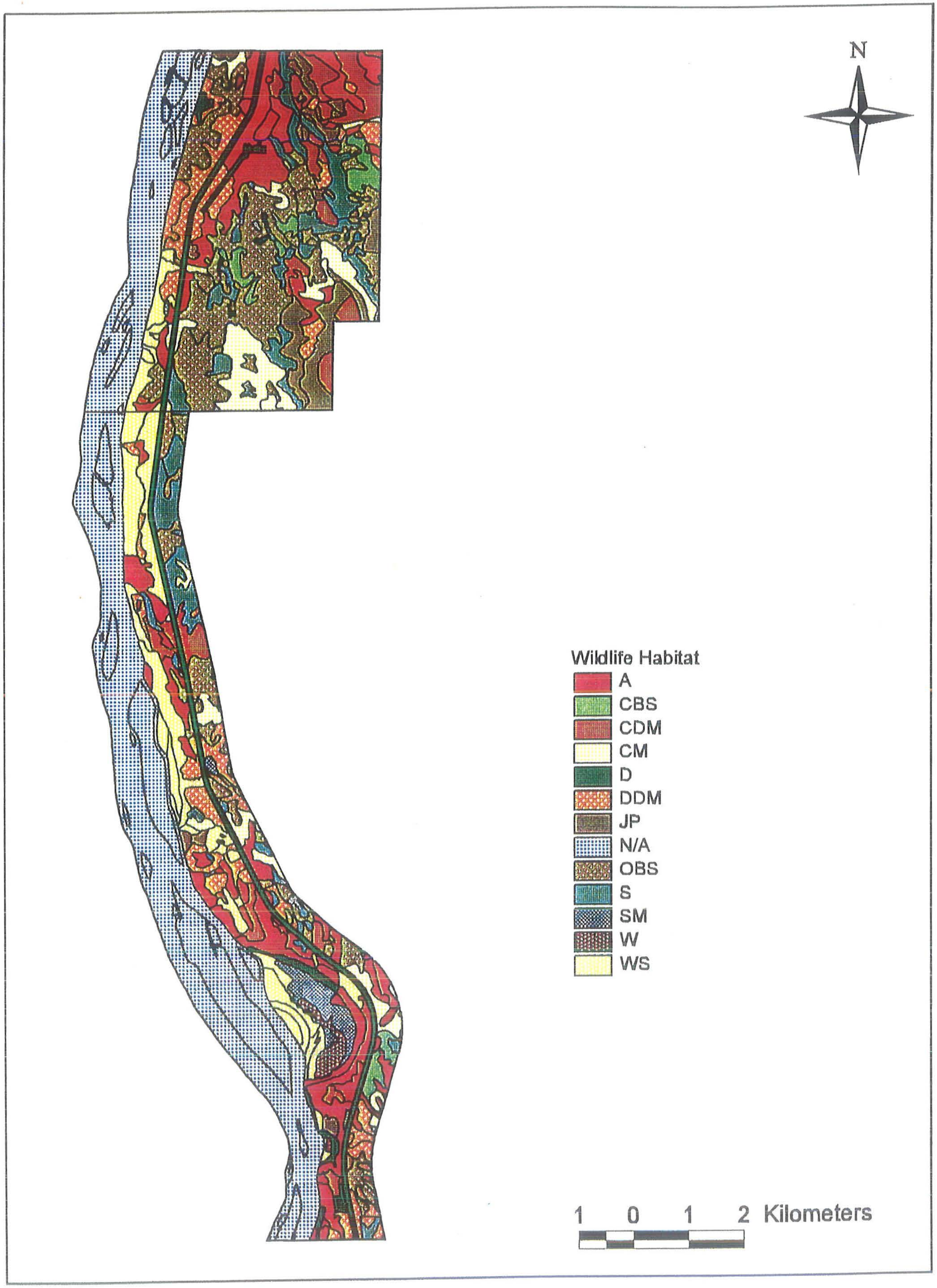


Figure 4.30 Habitat types in the Local Study Area.

The shrub layer is composed largely of immature and underdeveloped black spruce, with Labrador tea, cinquefoil, willow and bog birch occurring sporadically. The moderately dense herb layer consists of dwarf willows, false solomon seal, and blueberry. Sedges, bog cranberry, cloudberry and occasional sundew also occur. There is a well developed non-vascular layer, and the litter layer is sparse.

This habitat type occurs extensively and is distributed widely throughout the LSA.

Aspen

This seral habitat typically occurs on the dry, upland ridges. It is characterized by a dense tree stratum of almost pure aspen. The shrub layer is dominated by alder, low-bush cranberry and prickly rose. The composition of the herb stratum is variable; common species include bearberry, bunchberry, blueberry, wild sarsaparilla, wintergreen and twinflower. A well-developed litter layer is present. In the absence of fire or other perturbations, this habitat is generally replaced by white spruce forest through natural succession.

Aspen habitat occurs throughout the LSA in scattered stands. A large stand is located around the north end of the Bitumont Airstrip.

White Spruce

This climax habitat is characterized by semi-open to dense stands of mature white spruce and balsam fir, with scattered occurrences of aspen and paper birch. Most sites have a semi-open to open shrub stratum composed largely of immature fir and spruce, prickly rose, alder and, to a lesser extent, low-bush cranberry, willow, aspen and occasional saskatoon. The herb layer is variable, but bunchberry, low-bush cranberry, twinflower and palmate-leaved coltsfoot are most common. Other species such as starflower, mitrewort, dewberry and wintergreen are present. A dense cover of feathermosses underlies most of the herb stratum and lichens, such as reindeer moss, may also occur.

White spruce types are found mainly along the Athabasca River escarpment.

Coniferous Dominated Mixedwoods

This is a seral community comprised of jackpine and trembling aspen, with occasional white spruce. Older stands are open, with mature jackpine and large aspen dominating the tree stratum. Young forests comprise dense stands of low jackpine with a poorly developed shrub and herb layer. Litter is also lacking. The shrub stratum is open and comprised largely of alder, with scattered willow and regenerating spruce. Bog cranberry, twinflower and bunchberry are the dominant herbs. Prickly rose, dewberry, wild sarsaparilla, strawberry and bedstraw are among other herbs occurring frequently in the herb stratum. A patchy moss layer, composed of feathermosses and litter, make up the remainder of the ground cover.

Coniferous dominated mixedwoods are scattered throughout the LSA.

Shrub

This habitat type is a successional stage between the emergent sedge meadows and the drier upland sites, occurring on poorly drained soils. This habitat type is characterized by open mature willows interspersed with wet sedge meadows.

Shrub habitat occurs throughout the LSA, but is most predominant parallel to the major waterways such as Fort Creek.

Sedge Meadow

This habitat type is composed of wet sedge meadow communities. The herbaceous layer is dominated by sedges, with graminoids occurring to a lesser degree.

This habitat has developed along short stretches of watercourses, where beaver dam-related flooding has persisted for several years.

Mixed Coniferous

Comprised of either jackpine-black spruce or a jackpine-white spruce mix, this habitat occupies ridges between black spruce forests and upland pine regions, or occurs as island ecotypes in aspen-spruce forest types. Mixed conifer forest represents the successional stage between pine and spruce-dominated forests. The shrub understory is composed of regenerating spruce, with some prickly rose and willow. The low shrub/herbaceous layer is commonly comprised of bunchberry and twinflower, with minor occurrences of other species including blueberry, bog cranberry, Labrador tea, fireweed, dewberry, wintergreen and starflower.

Mixed coniferous types are scattered through the LSA.

Deciduous Dominated Mixedwood

Aspen-spruce mixed forests occur on drier, well-drained upland portions of the Study Area and represent a transitional stage between aspen and white spruce forest. They are dominated in the tree stratum by aspen, although white spruce and paper birch also occur. Willow, young aspen, low-bush cranberry and prickly rose dominate the shrub layer along with regenerating white spruce. Bunchberry, wild strawberry and dwarf shrubs such as blueberry dominate the herb stratum. In conjunction with the herbs and low shrubs, plant litter provides a dense ground cover.

Deciduous dominated mixed wood is found in an area around the Bitumont Airstrip and along the Athabasca River near white spruce stands.

Jackpine Forest

Jackpine habitat occurs on sandy textured soils with good to fair drainage. Although commonly considered a seral habitat, which is replaced by white spruce, this habitat can be persistent on well-drained sandy soils. The shrub stratum is almost non-existent. The open herb stratum is primarily composed of common bearberry, blueberry and wild lily of the valley. There is a small amount of sparsely distributed litter.

Jackpine forest are found in small isolated stands throughout the LSA.

Closed Black Spruce

This habitat typically occurs on poorly drained sites with moist to wet soils. It supports a moderately dense tree stratum of black spruce, and a shrub stratum comprised of regenerating spruce and, to a lesser extent, Labrador tea, prickly rose and occasional bog birch and willow. The herb/low shrub layer is overshadowed by Labrador tea and is sparse, but diverse (including bog cranberry, bunchberry, twinflower, cloudberry, dewberry, currants, wintergreens and bedstraw). The dense moss layer is composed mostly of feathermosses, while peat moss becomes more common in wetter sites. Litter cover is moderate, and is usually overgrown by non-vascular vegetation.

Black spruce forest occurs throughout the LSA and is relatively common.

4.7.2.2 Aquatic Habitat Types

Aquatic habitat in the Local Study Area includes the Athabasca River and Fort Creek.

- The importance of the Athabasca River for wildlife has been discussed in Section 4.7.1.1.

- Fort Creek has been modified substantially by damming by beaver. The channels are poorly defined and ponding is extensive. Habitat adjacent to the tributaries is sedge-reed grass or willow/bog birch shrub. As a result of the stagnant waters of beaver ponds, oxygen concentrations in the tributaries are low and the creeks can support only forage fish species (i.e., brook stickleback and lake chub). The tributaries offer limited habitat for waterbirds, but good habitat for beaver.

- Isadore's Lake, an oxbow lake along the Athabasca River and at the south end of the LSA offers some potential for waterfowl. Alberta Land Inventory (1972) identifies this area as having severe limitations to waterfowl production due to adverse topography and free flowing water.

4.7.2.3 Important Wildlife Populations/Use Areas

Ungulates

Although Alberta Fish and Wildlife rates the Athabasca River as providing important winter habitat for moose, late winter aerial surveys of the LSA in March 1995, found low densities of **moose**, i.e., 0.01 moose/km^2 (Appendix VII). Although three sets of moose tracks were observed in the vicinity of Fort Creek, none was observed in the LSA during track surveys rather than low value of habitat as winter range. The milder 1994-95 winter may have been a factor in the limited use of the riparian habitat along the Athabasca River. Although observation during ground surveys suggest that there is little available browse for ungulates within the Study Area except along river breaks, the Athabasca River may still be an important movement corridor for wildlife. Traditionally the LSA was considered an important area for moose hunting by aboriginal people (Fort McKay Environmental Services 1995).

The most important habitats for moose in the LSA, based on regional studies, are Aspen, Mixedwood and Shrub habitats. Within the Athabasca region, moose primarily utilize deciduous forest, mixedwood forest and willow shrubland, with lowland habitat, such as open muskeg, black spruce forest and black spruce-tamarack forest seldom being used (Green 1983; Hauge and Keith 1981; Knapik and Westworth 1982; Penner 1976; Westworth 1979*b*, 1980). Typically, moose will utilize lowland habitats more in the summer than in winter, moving into the uplands as snow depth increases (Green 1983; Hauge and Keith 1980). Hauge and Keith (1980) note that if there is a critical habitat for moose in the Regional Study Area, it is the open lowlands that provide first high quality food in spring.

Shrub habitats are found only along Fort Creek within the Study Area. In addition, edge habitats that include tall shrub (provide high food value) adjacent to mixedwood, closed black spruce or deciduous (provides moderate to high value cover) provide high quality habitat for moose. Habitat of moderate value due to limited browse are aspen dominated mixedwood, aspen-white spruce and white spruce, or due to limited cover are tall shrub, deciduous and clearcut habitat.

No deer were seen during aerial surveys of the LSA, but two sets of tracks were observed along the winter road to Fort Chipewyan.

The presence of a salt lick is noted by Fort McKay Environmental Services (1995; Appendix V) along the Athabasca River, south of the mine site. The location should be protected (Figure 4.28).

Furbearers and Carnivores

Based on furbearer harvest data from Registered Trapping Areas in the LSA (i.e., RTAs 1650, 2137 and 2006), and the March 1995 track inventory the most common terrestrial furbearers and carnivores in the vicinity of the LSA are snowshoe hare followed by red squirrel and then fisher, weasel, fox, coyote, lynx and marten.

Fur harvest returns data for 1983-84 to 1992-93 indicated that although 28 **wolves** were trapped in RTA, 2137 in the 1986-87 season, no other wolves have been trapped on this or other RTAs in the LSA. Wolves are not abundant in the Study Area. Based on 1978 radio-collared inventories, the range of the Muskeg River wolf pack, i.e., 10 wolves, includes 1023 to 1627 km^2 and encompasses the LSA, although most activity is concentrated within 15 km of Kearl Lake (approximately 30 km southeast of the Study Area). The range of the Black Pack wolf pack, i.e., 3 wolves, encompasses the mouth of the Muskeg River (Fuller and Keith 1980*b*). Densities associated with these two wolf packs were estimated to be 0.78 animal/100 km^2 for the Muskeg River Pack and 0.84 animal/100 km^2 for the Black Pack. The diet of the wolves in the Muskeg River Pack was 53% moose, 31% beaver, 12% hare and 4% other; that of the Black Pack was

21% moose, 52% beaver, 18% hare and 9% other (Fuller and Keith 1980*b*). Low moose numbers and the lack of open/disturbed may account for the low moose densities in this area.

- **Snowshoe hare** undergo periodic fluctuations in population size and prefer habitats dominated by aspen and spruce forest (Penner 1976). Aspen and aspen-white spruce habitats showed the highest use during track surveys in March 1995 (Appendix VII).

- Despite high number of **red squirrels** observed on March 1995 track inventories relative to other furbearers, the LSA does not provide good squirrel habitat due to its lack of mature conifers (especially white spruce). Track surveys indicate white spruce habitats had the highest use by squirrel within the LSA (Appendix VII). Coniferous forest represents the preferred habitat of red squirrels (Green 1979; Penner 1976, 1985), although they may also be found in mixedwood, and sometimes, deciduous forests (Flyger and Gates *in* Chapman and Feldhamer 1982). The distribution of the red squirrel is closely related to that of coniferous forests and the availability of spruce cones for food (Brink and Dean 1966, Reige 1976, Wood 1967). Counts of active squirrel middens indicate that white spruce forest is the most heavily used food source (8.7 middens/ha), followed by jack pine (2.6 middens/ha), mixedwood (1.0 to 2.6 middens/ha) and high density black spruce forest (1.9 middens/ha) (Penner 1976, *in* Sopuck *et al.* 1979).

- Track surveys in the LSA in March 1995 found **fisher** tracks in all habitat types within the LSA. Literature suggests that dense coniferous forest and mixed forests with high cover are preferred habitats for fisher (de Vos 1951, Kelly 1977, Raine 1983). Track survey results were too scant to determine clear habitat preferences for fisher.

- **Weasels** were found in all habitats in the LSA during 1995 track surveys. This species is an opportunistic feeder utilizing a wide variety of prey species.

- **Fox** tracks were found in low densities in all habitats except white spruce habitats (Appendix VII).

- Fur harvest data for the Registered Trapping Areas (RTAs) 1650, 2137 and 2006, located in the LSA, indicate only low numbers of **coyote** (0.3 animals on average/year) were trapped between 1982 and 1991, inclusive (Table 4.24). Track surveys conducted on the LSA in March 1995 showed **coyote** track densities of 0.72 tracks/km (Appendix VII).

- Lynx tracks observed during track surveys conducted in March 1995 showed a low numbers of animals in all habitat types (see Appendix VII).

- **Marten** tracks were only observed in one Black spruce site during track surveys in March 1995, and low numbers of Marten have been trapped between 1983 and 1993.

Fort Creek, which has been heavily dammed by beaver, provides good habitat for this species, due to its moderate to abundant willow and aspen and several deeper ponds that should permit access to winter food caches. Fort Creek also provides moderate quality habitat for mink. Mink activity is usually highest in undisturbed riparian, aspen-willow and deciduous-dominated mixedwood (Penner 1976). However, the lack of streams containing fish (except small forage species) and muskrats may, however, mean that food is limiting.

Terrestrial Birds

Upland game bird densities observed in the LSA during March 1995 track inventories are shown in Table III.3 (Appendix VII). Grouse track densities were highest in aspen and aspen-white spruce habitats. Spruce grouse are expected to be fairly abundant in habitats containing a high percentage of conifers such as muskeg and spruce woods, while ruffed grouse will increase in abundance in deciduous or mixedwood habitats.

Raptors typically have home ranges that are large compared to the LSA. There are 22 raptor species potentially occurring within the LSA (Appendix VI).

The densities of woodland terrestrial birds from several studies in the oil sand region are summarized in Table 4.24. Three plots from the Francis and Lumbis (1979) study were located in the LSA, one was on Lafont Island just north of the bitumont historic site on the Athabasca River and an Aspen and Muskeg plots were located within the LSA. All three plots showed densities of terrestrial birds that were within the ranges shown in Table 4.24.

Special Status Species

Of the special status species noted in the BCESA, the species that would be most likely to be found occasionally at very low densities in the LSA based on habitat types, are the wolverine and great grey owl, and in higher numbers is the lynx.

In summary, the quality of the major terrestrial habitat types for wildlife species were evaluated with the following conclusions:

- Open Black Spruce, which covers 19% of the LSA, provides low to moderate quality habitat for wildlife.

- Aspen, which covers 17% of the LSA provides moderate to high quality habitat for most species of wildlife.

- Deciduous and Coniferous Dominated Mixedwoods, which covers approximately 17% of the LSA, provides high and moderate quality habitat for all wildlife due to diversity and more complexity in the plant species present.

- White Spruce habitats, which covers 11% of the LSA, provide good quality habitat for red squirrel and provides good thermal cover for wildlife during winter months.

Table 4.24 Breeding bird plot censuses information for the oil sands area.

	Territories/100 ha			
	Black Spruce	**Aspen-White Spruce**	**White Spruce-Aspen**	**Jack Pine**
Hennan *et al.* (1977)	67-91	147-453	430-515	67-91
Francis and Lumbis (1979)	418-571	142-515		67-87
McLaren and Smith (1985)	205-260	355-770	254-364	133

- Shrub habitat covers a little over 17% of the LSA and provides high quality habitat for snowshoe hare, moose and other small mammals. The value of this habitat for other wildlife species is low.

- Mixed coniferous, which covers 7% of the LSA and offers thermal cover for wildlife as well as food sources for squirrel. This habitat is rated as moderate for wildlife.

- Sedge meadows, which covers 7% of the LSA is associated with wetlands and provides low to moderate quality habitat for wildlife.

- Jack pine, which covers 6% of the LSA, stands offer little shrub understory for wildlife to exploit. The value of this habitat for wildlife is low for most species.

4.8 Fisheries and Aquatic Resources

4.8.1 *Athabasca River Mainstem*

4.8.1.1 Physical Environment

The Athabasca River borders the Solv-Ex Lease 5 for about 7 km. This portion of the Athabasca River is located within a 125 km reach displaying similar physical and hydrologic conditions throughout, and extending from Fort McMurray downstream to the Firebag River. An average river gradient of 0.17 m/km produces low to moderate currents of approximately 1.0 m/s. Numerous islands, point bars and mid-channel sand bars occur throughout this portion of the river (Canadian Hydrographic Service Chart 6301, 1973). R.L. & L. (1993) characterized this reach as having a combined multiple island (54%) and unobstructed (35%) channel type. A 9.5-km study site (Site 9) just upstream of the Solv-Ex lease exhibits a higher proportion of multiple channel type (91%; Table 4.25); often exhibiting more than two channels, with permanent islands present and extensive sidebars and mid-channel bars present at low flows. Banks within this area are predominant steep and eroding, or unstable. Bed material in this reach is generally sand/silt, gravel over limestone, limestone cobble, and tar sand (bitumen).

No major tributaries enter the Athabasca River within the Solv-Ex Study Area, although three larger tributaries (the Calumet, Tar and Ells rivers) are located within a short distance (< 5 km), on the west side of the river. One small tributary, Fort Creek, is present within Lease 5.

Earliest and latest dates for ice break-up on the Athabasca River are 15 April and 7 May, with the average date being 28 April. During mid-May 1992, mainstem water temperatures of 11°C, water clarity of 0.28 m (Secchi reading) and a conductivity of 268 mS/cm were recorded in this portion of the river (R.L. & L. 1993). Water temperatures reach a normal maximum of 18 to 20°C in July, although temperatures of 24 to 26°C have been reported (R.L. & L./A.A. Aquatic Research 1984). Freeze-up ranges from 22 October to 18 November, with the average date being 5 November.

Table 4.25 Percent composition of major channel and bank habitat types at Site 9, Athabasca River, spring 1992. This site is approximately 15 km upstream of the Solv-Ex facility (R.L. & L. 1993).

Major Channel Type[a]	Length (km)	Percent Composition	Bank Habitat Type[b]	Length (km)	Percent Composition
U	0.7	7	A1	1.9	8
S	0.2	2	A2	0.3	1
M	8.6	91	C2	0.2	1
			D1	3.5	14
			D1	3.5	14
			D2	0.3	1
			E1	12.6	52
			E2	5.7	23
			A1/C1	0.1	<1
Total	9.5	100		24.6	100

(a) U - Unobstructed Channel; S - Singular Island; M - Multiple Island.

(b) A - Armoured/stable; C - Canyon/bedrock; D - Depositional; E - Erosional, Complete habitat codes and descriptions are presented in R.L. & L. 1993 (Appendix B2)

Peak discharges below Fort McMurray normally occur in July, with a long-term mean monthly minimum discharge of 1460 m^3/s in February (Environment Canada 1985).

4.8.1.2 Aquatic Resources

Fish Populations

Several studies of mainstream Athabasca River fish populations have been undertaken in the vicinity of the oil sands leases in relation to proposed or existing developments. McCart *et al.* (1977) sampled fish populations during a study of aquatic resources in 1974 and 1975, and Bond (1980) and Bond and Berry (1980) conducted more detailed studies of fish populations in 1976 and 1977. Syncrude Canada Ltd. (Van Meer 1992) initiated a fisheries baseline and impact monitoring program in the Athabasca River, with an initial survey in 1987 and subsequent sampling programs performed in 1989, 1990 and 1991. Recently, sampling has been conducted as part of the Northern River Basins Study (NRBS). During a 1992 fish and riverine habitat inventory of the Athabasca River, both mainstem and major tributary sites were examined (R.L. & L. 1993).

McCart *et al.* (1977) sampled approximately 35 km of the Athabasca River, from a point just upstream of the Suncor lease to a point just downstream of Haight Island. Sixteen fish species were captured using seining and backpack electrofishing. Goldeye, walleye, longnose sucker, lake whitefish and northern pike were the most common larger species encountered.

Bond (1980) and Bond and Berry (1980) had a study area which extended for 135 km from the mouth of the Horse River (upstream of Fort McMurray) to the mouth of the Firebag River. They captured a total of 27 species by a variety of methods, including gillnets, angling, large mesh seines and small mesh seines.

The study area for the Syncrude Canada Ltd. monitoring program (Van Meer 1992) extends for approximately 54 km from the confluence of Poplar Creek downstream to Sutherland Island (2 km upstream of the Solv-Ex study area). Boat electrofishing has been used for all sampling. Fifteen species have been encountered in the study area. Amongst the species of sport, subsistence, or commercial fisheries significance, goldeye and walleye were most abundant. Flathead chub and trout-perch were the most abundant of the forage and minnows species group, with the combined sucker spp. (juveniles) and shiner spp. groups also common.

R.L. & L. (1993) sampled two sites in the mainstem Athabasca River between the Muskeg River and the Embarrass River during spring 1992. The uppermost site (Site 9) was closest to the present study area, and ended at a point downstream of Haight Island, approximately 15 km above the Solv-Ex lease boundary. Tributaries in the reach also were sampled, including the lower Tar River and Pierre River located 2 km upstream and 6 km downstream, respectively, of the lease area. Fish were sampled by boat electrofishing, seines, set-lines, gillnets and driftnets. The determination of fish use patterns with respect to habitat availability or preference was an important component of the sampling program. Extensive habitat mapping and measurement was conducted in addition to collecting information on fish distribution and relative abundance. Intensive survey sites were benchmarked for future reference and data collected was geo-referenced (UTM coordinates using GPS). Fish for contaminant analysis were also collected.

Fourteen fish species were recorded from Site 9. Management and subsistence important species included lake whitefish, walleye, northern pike, goldeye, longnose sucker and white sucker. Walleye was the dominant species, contributing 34.4% to the sport and coarse fish species catch (Table 4.26). Larval stages of walleye were captured in drift nets. The presence of young-of-the-year in the catch, and the presence of numerous adults in spawning condition (i.e., ripe males and spent females), indicated spawning activity either in Reach 9, upstream reaches, or larger tributaries (e.g., MacKay River) within the reach. Suitable walleye spawning habitat was not identified in the mainstem Athabasca River in this immediate area.

Goldeye also were relatively abundant at Site 9 (Table 4.26), and were generally distributed in habitats characterized by moderate current velocities. All captured goldeye were adults. Suitable spawning habitats (e.g., large, quiet backwaters or side channels; Scott and Crossman 1973) were not recorded at this site. The lower Athabasca River may serve primarily as a summer feeding area for goldeye, which enter the study area prior to breakup and leave in late autumn (Bond 1980). These goldeye are thought to belong to the population that spawns in the Peace-Athabasca Delta.

Trout-perch and flathead chub were the most abundance forage fish species at Site 9. Lake chub, longnose dace, emerald shiner, and sculpins also were well represented in the catch.

The relative abundance of major sport, coarse and forage fish captured by boat electrofishing and seining during spring 1992 at Site 9 is illustrated in Figures 4.31 and 4.32.

The Athabasca River and its tributaries provide important spawning, feeding, and rearing areas for a number of fish species, and are believed to play a major role in the maintenance of the fish populations of Lake Athabasca (Bond 1980). Tagging results indicate that walleye, goldeye, lake whitefish, longnose sucker, and white sucker, found in the lower Athabasca River, belong to populations that overwinter in Lake Athabasca and the Peace-Athabasca Delta. During early spring, upstream spawning movements of walleye, longnose sucker, and white sucker occur in the Athabasca River. Major spawning areas for walleye and sucker sp. have been identified on the Clearwater River and in the rapids upstream of Fort McMurray. Spawning by these species also occurs in varying degrees in smaller tributaries to the Athabasca River and may also occur around islands or suitable point bar habitats in the mainstem Athabasca River.

During spring and early summer, the fry of many fish species appear in the Athabasca River in the vicinity of the Local Study Area. These fry originate from mainstem and tributary spawning sites, many of which are upstream. Most of the fry do not remain in the area, but are carried further downstream to nursery areas in the Lower Athabasca River or Lake Athabasca.

During early fall, a large upstream spawning migration of lake whitefish occurs. The major part of this run passes the study area by early October, with most fish continuing upstream to spawn in the mainstem Athabasca River below the Mountain/Cascade Rapids above Fort McMurray (Jones *et al.* 1978). Some whitefish return to Lake Athabasca shortly after spawning, but others may overwinter in the Athabasca River.

Table 4.26 Fish species composition at Site 9, Athabasca River, spring 1992 (R.L. & L. 1993).

Sport and Coarse Fish Species	Size-classes		Total Captured[b]	%	Forage Fish Species	Total Captured[b]	%
	Y-O-Y	Juv/Ad[a]					
Lake whitefish		√	1	3.1	Flathead chub	137	36.2
Northern pike		√	3	9.4	Lake chub	32	8.5
Walleye	√	√	11	34.4	Longnose dace	9	2.4
Goldeye		√	8	25.0	Emerald shiner	26	6.9
Longnose sucker	√		4	12.5	Fathead minnow	2	0.5
White sucker		√	5	15.6	Trout-perch	162	42.9
					Spoonhead sculpin	6	1.6
					Sculpin spp.	2	0.5
					Sucker spp. (unident.)	2	0.5
Total			32	100		378	100

(a) Combined due to difficulty in differentiating between these life stages based solely on size.
(b) Data for all sampling methods combined.

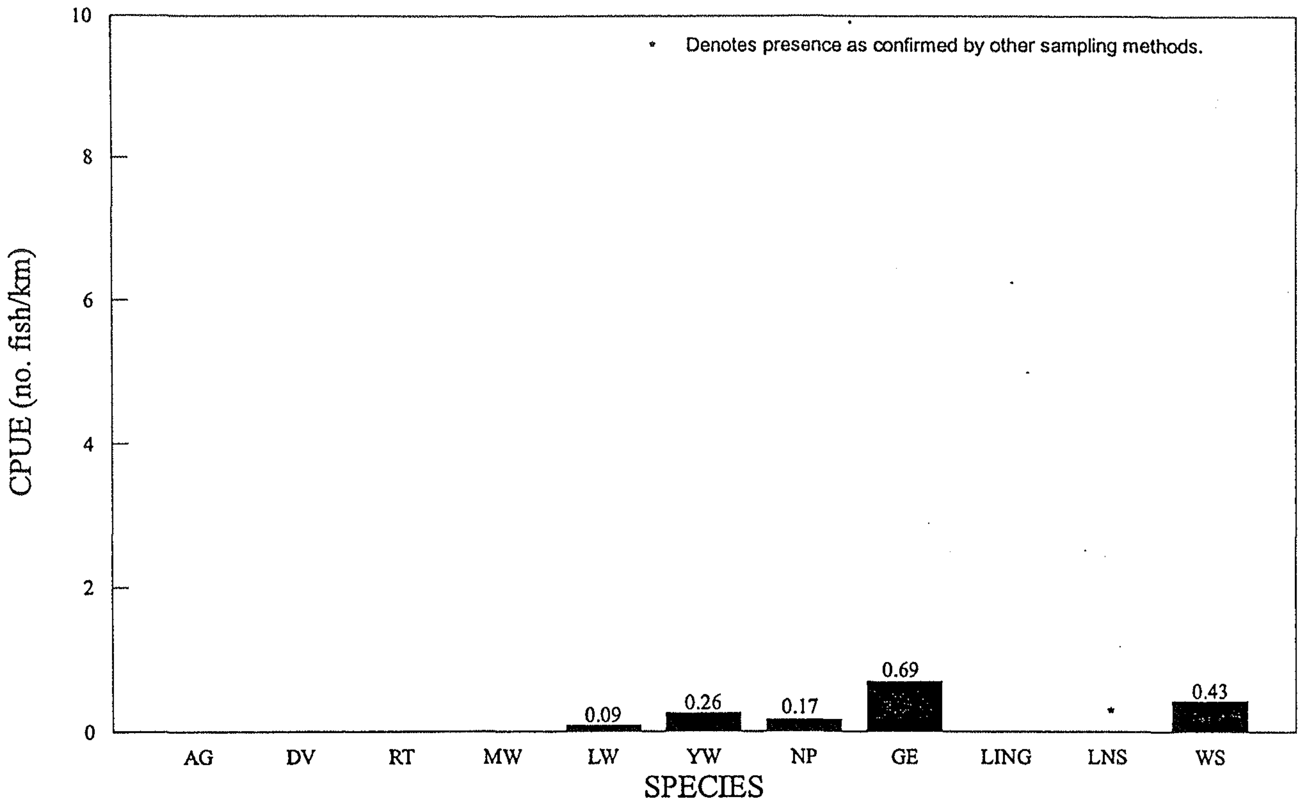


Figure 4.31 Catch-per-unit-effort values for sport and coarsefish captured by boat electrofishing at Site 9, Athabasca River, spring 1992.

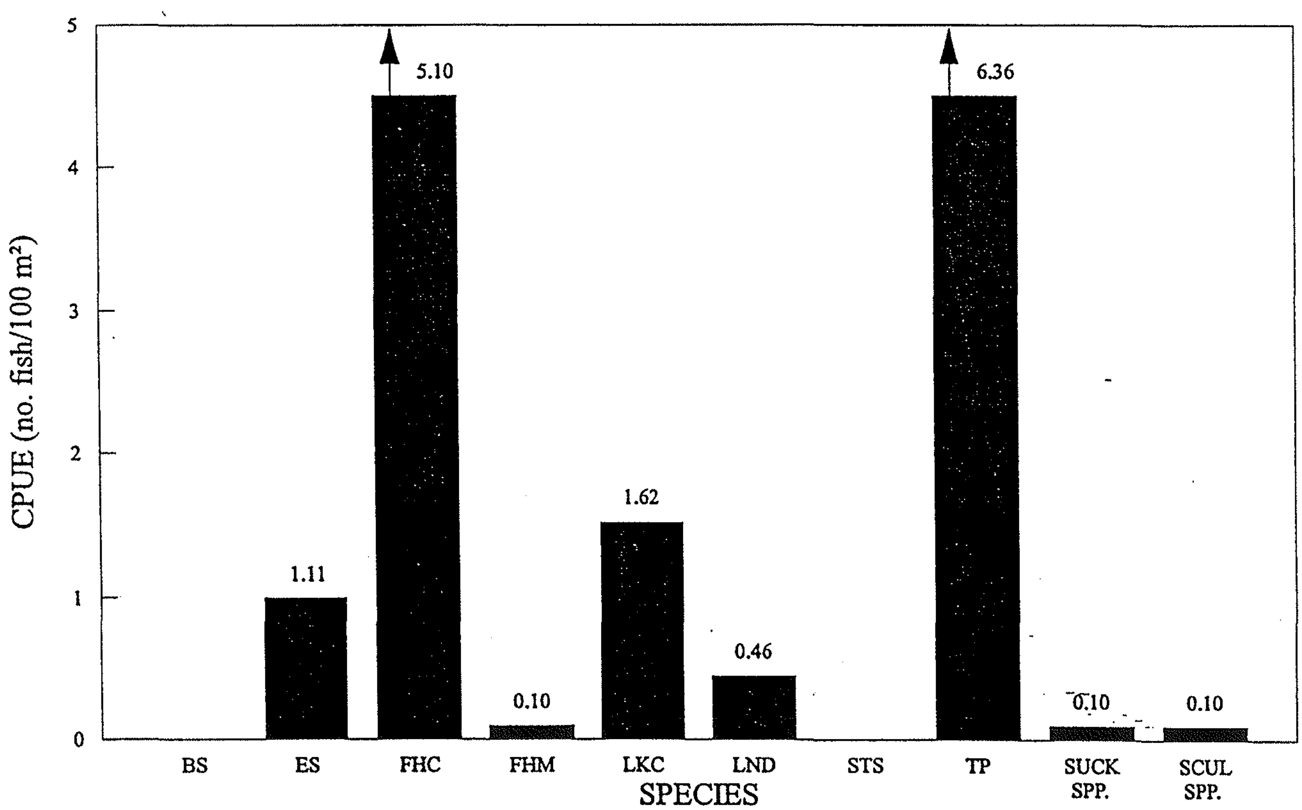


Figure 4.32 Catch-per-unit-effort values for forage fish captured by beach seining at Site 9, Athabasca River, spring 1992.

The Athabasca River also provides feeding and overwintering habitat for local populations of species such as Arctic grayling and northern pike. Arctic grayling are rarely encountered in the mainstem river until late fall, at which time they leave shallow tributaries in the region and move into the Athabasca River to overwinter.

Northern pike have been collected from the mainstem Athabasca River during all seasons (R.L. & L. 1993, Van Meer 1992), and are often common near the confluence of tributaries and in shallow backwaters and channels. This species does not generally exhibit lengthy migrations but undertake short spawning movements in the spring from the mainstem into some tributaries in the area (Pattenden and O'Neil 1991). Mainstem spawning may also occur in areas of flooded sidechannels or vegetation debris.

Benthic Invertebrates and Periphyton

There have been several studies of benthic invertebrates in the mainstem Athabasca River in the tar sands development areas. These have been reported or summarized in Barton and Lock (1979), Barton and Wallace (1980), Boerger (1983), McCart *et al.* (1977), and Noton (1979). Only the 1975 studies (McCart *et al.* 1977) and 1981 studies (Boerger 1983) contained sites approaching the upper boundary of the present Local Study Area. Intensive benthic invertebrate programs have not been undertaken on the mainstem Athabasca River since 1981.

In 1975, samples were collected using artificial substrate and an Ekman grab, at 15 stations along a 35 km stretch of river from upstream of Suncor to Haight Island, downstream of Fort MacKay (McCart *et al.* 1977). The invertebrate fauna in their samples was dominated by Diptera and Oligochaeta, with Ephemeroptera and Plecoptera as sub-dominants. Most (77%) of the Diptera were chironomids. In spite of the occurrence of bitumen in the substrate at some sites, no significant difference was found in the benthic community structure between sites with and without bituminous substrate.

The 1981 study on the mainstem Athabasca River involved collection of benthic invertebrates from 16 sites along an 85 km stretch of river between Fort McMurray and the Ells River (Boerger 1983). Overall, the fauna was dominated by Chironomidae (53% of total density), Ephemoroptera (21%) and Oligochaeta (18%). There were no site-specific differences in number of taxa, or in Shannon-Weaver diversity. Sites downstream of the Suncor plant had an average density 31% lower than sites upstream. However, an analysis of benthic and water quality data found no evidence of large differences which were attributable to the Suncor effluent (Walder and Mayhood 1985). Higher densities immediately downstream of Fort McMurray were attributed to the influence of drainage from the Clearwater River and an enrichment by effluent from the Fort McMurray sewage treatment plant.

There is little information on periphyton communities in the mainstem Athabasca River. McCart *et al.* (1977) examined epiphytic algal communities which developed on artificial substrates at mainstem sites in the vicinity of the Syncrude development. In total, 191 algal taxa were identified, of which 60% were diatoms, 20% were Chlorophyta, 10% were Cyanophyta and 10% were non-diatom Chrysophyta. The total amount of organic matter (detritus, bacteria and algae) increased from 100 mg/m^2 in the late winter to 705 mg/m^2 in summer. These values suggest that benthic organisms in the river have an abundant supply of food.

4.8.2 *Fort Creek*

Fort Creek has a total length of about 12 km and drains the south and west slopes of the Fort Hills. If flows across the northeastern portion of the Solv-Ex lease and enters the Athabasca River approximately 1 km downstream of the northern boundary of the site.

No published data is available on the aquatic biota or water quality of the stream. Numerous beaver dams are reportedly present and thus likely limit fish use to the lowermost portion and confluence with the Athabasca River. Steep gradients are also encountered in the lower 2 km of stream. Fish species, if present, are expected to be tolerant forage/minnow species such as fathead minnow which are found in similar small streams and muskeg drainages within the oil sands area. Limited seasonal use (e.g., spring) of the mouth or any accessible portion of the lower reach of the stream may be expected by northern pike and coarse fish (sucker sp.).

4.9 Resource Use

Resource use discussed for the Local Study Area (LSA) include: forestry and agriculture, and for the Biophysical Cumulative Effects Study Area (BCESA) include land use zoning, natural areas, ecological reserves and environmentally sensitive areas, consumptive resource use (hunting, trapping, fishing, aggregate resource use) and non-consumptive resource use (recreation).

Access to the Solv-Ex Project Area is along the summer road or the Fort Chipewyan winter road which parallel the Athabasca River. This access is also used for both consumptive and non-consumptive resource use activities in the area.

Information on resource and traditional uses by the Fort McKay people has been compiled in two recent publications (Fort McKay Environment Services 1995). In the fall of 1989 a Traditional Pursuits Study (Concord Environmental Corporation and RMC 1990) was conducted to evaluate hunting, trapping and fishing activities of First Nations People in the vicinity of the OSLO project area. Interviews of 27 First Nations people were conducted and information collected by Fort McKay Environmental Services Ltd.

4.9.1 *Land Use Zoning, Natural Areas, Ecological Reserves and Environmentally Sensitive Areas*

The Biophysical Cumulative Effects Study Area is located in the Green Zone of Alberta, which contains forested lands that are managed for multiple use, including forest production, water, recreation, fish and wildlife, and industrial development. The Solv-Ex development site is located about 70 km north of Fort McMurray and 20 km north of Fort McKay. The project will affect lands within Townships 96 and 97, Ranges 10 and 11, West of the 4th Meridian. In addition, the upgraded Fort Chipewyan access road crosses in a north-south direction through the Study Area.

The Solv-Ex Development Area falls within the Municipality of Wood Buffalo (formerly I.D. 18). The purpose of the Municipality is to regulate and control the use and development of land and buildings to achieve orderly and economic development of land. Discretionary land uses allowed in the district are: natural resource extraction industries, natural resource processing industries, transportation and utility facilities, trapping, and fish and wildlife conservation.

The Development Area is located within the proposed "Fort McMurray - Athabasca Oil Sands Sub-regional Integrated Resource Plan" (IRP) area, which is currently being developed under the direction of the Alberta Land and Forest Service. This plan will provide a framework for developing and assessing future actions by both provincial government agencies and the private sector, of those resources and lands under the public domain. The Local Study Area is within the Clearwater-Athabasca and Mildred-Kearl Lakes Resource Management Areas defined by the IRP:

- The Athabasca-Clearwater Resource Management Area (Figure 4.33) has been established to protect the natural landscape that encompasses water, wildlife habitat, ecological and geological features for aesthetic, recreational, traditional and environmental values. Allowances for transportation-related activities, pipeline crossings, gravel development and timber harvesting, with adequate reclamation and protection planning, will be considered.

- The Mildred-Kearl Lakes Resource Management Area (Figure 4.33) has been established to promote the orderly planning, exploration and development of resources with emphasis on the area's oil sands reserves.

There are no Natural Areas or Ecological Reserves in the BCESA. The closest natural area is Saline Lake which is located approximately 35 km south of the Solv-Ex development site. This lake is a conservation area of 290 ha located on the east side of the Athabasca River. It is an oxbow of the Athabasca and supports several springs, mineral deposits and crystal formations. The lake is the most productive in the area for waterfowl, and ungulates are attracted to the spring as a salt lick. Rare vegetation species are known to occur at this site. The La Saline spring has a large tufa deposit (calcium carbonate cone) that is unique in the region.

Several environmentally sensitive areas are located within the BCESA (Westworth 1990). These areas include the following sites:

- McClelland Lake and its associated wetland is located approximately 15 km northeast of the Solv-Ex Lease. This area is considered to be a significant natural feature as a result of the karst geological structure which has formed numerous sinkhole lakes in this area. The area also includes patterned fens and is noted as an important waterfowl staging area and a bald eagle nesting site.

- The Fort Hills are located immediately to the northwest of the Solv-Ex development site and are partially included within the Local Study Area. These hills are a significant natural feature displaying dissected kame glacial geological characteristics. The area is important for wildlife habitat, including moose and lynx.

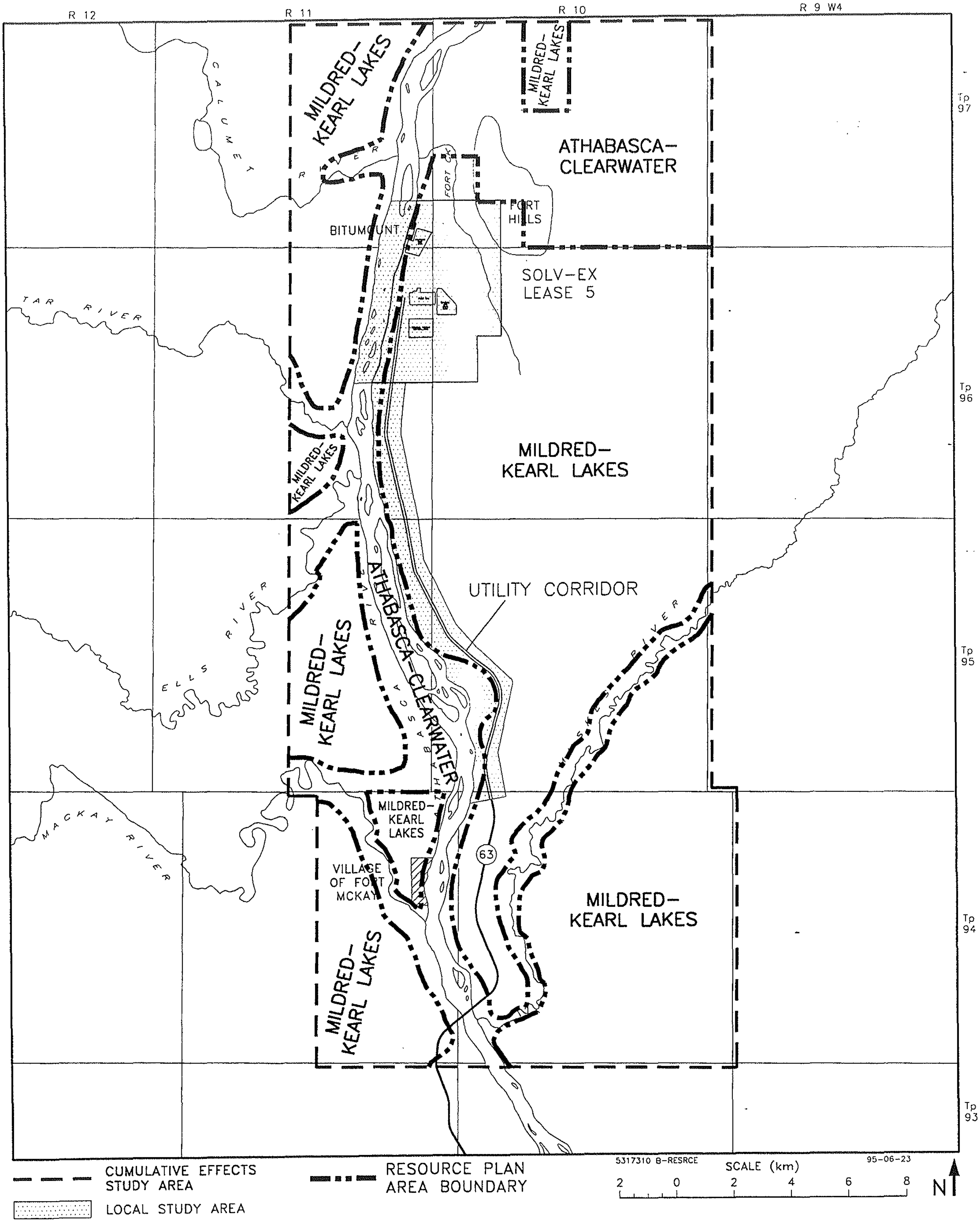


FIGURE 4.33 FORT McMURRAY-ATHABASCA OIL SANDS SUBREGIONAL INTEGRATED RESOURCE PLAN

- The Athabasca River north of the confluence of the Clearwater River is considered to have nationally significant natural features. These features include fluvial features of floodplains, sand and gravel bars, bitumen outcrops and point bars. The river also provides an important sports fishery for walleye, lake whitefish, arctic grayling, northern pike and goldeye.

- The Calumet River provides important otter habitat and a wildlife movement corridor.

- Old growth forests are noted to occur in the vicinity of the confluence of the Calumet River and the Athabasca River and along the banks of the Ells River.

4.9.2 Forestry

The LSA and BCESA are part of Forest Management Unit (FMU) 7. FMU 7 lies within the Alberta Pacific Forest Industries Ltd. Forest Management Agreement (FMA) area. The area is also within the quota sphere of Northlands Forest Products Ltd. Alberta Pacific is primarily interested in the mature deciduous timber while Northlands utilizes the coniferous timber.

Alberta Pacific is planning to harvest timber in this region during the winter of 1997/98. Harvesting is to begin in Township 97, Range 9, West of the 4th Meridian in 1997 and move to Township 98, Range 7 in 1998 (Don Pope, Planning Forester, pers. comm.). During harvest approximately 40 truck loads of wood per day will be removed from this area and transported to the mill at Grassland. The trucks will use Highway 63 to cross the Athabasca River.

Northlands Forest Products Ltd. uses the Fort Chipewyan road during the winter as a truck haul route for timber harvested on both sides of the Athabasca River. Log hauling is usually limited to a 2 month period during which there are approximately 20 trucks each day (G. Ehrentraut, Woodlands Manager, pers. comm.). In 1996 timber harvested from Townships 101 to 103, Ranges 9 and 10 will be trucked across the Athabasca on an ice bridge and hauled along the Fort Chipewyan winter road to Fort McMurray. Beginning in 1997 timber will be harvested in Township 98, Ranges 11 and 12 and Township 97, Ranges 8 and 9. Harvesting east of the Athabasca River in 1997 will include areas in Township 98, Ranges 8, 9, 10 and 11.

Forest capability for the former Alsands oil sands lease, to the southwest of the Solv-Ex site, was rated using the Alberta Land Inventory classification system, into Classes 5 to 7. These classes have severe to very severe limitations for productivity (Hardy Associates [1978] Ltd. 1981). The major capability limitation for forestry in the region is the short, cool growing season. Other limitations include too much or too little soil moisture, and a deficiency of plant nutrients in the soil.

Forest capability in the Local Study Area corresponds to the findings reported for the Alsands oil sands lease (Figure 4.34). All sites have severe to very severe limitations. The sites with the least restriction to forest capability are located on upland ridges, the Fort Hills or the banks of the Athabasca River. These sites all have Dystric Brunisolic soils of either the Mildred or Firebag soil associations.

Very little information is available on the productivity of the forests in the region. At the present time, productivity of the forest cover types in the region is determined using forest cover maps and volume tables developed for Volume Sampling Region 8. The volume tables for this region are primarily based on inventory data from the Lac La Biche area, which is located in the southernmost portion of the Volume Sampling Region 8 (G. Ehrentraut, pers. comm.). FMU 7 has fewer merchantable sites and less productive area (G. Ehrentraut, pers. comm.). Therefore the volume tables are not entirely applicable to the oil sands region as they tend to over-estimate the productive volume available.

In the Local Study Area, forest productivity for both deciduous and coniferous timber is highly variable (based on a 15 cm stump, diameter outside bark, and 11 cm minimum top diameter) (Alberta Forest Service 1985). Bog and fen areas produce negligible amounts of timber. Black spruce production is very low, however, some stand volumes are estimated to be as high as 112 m^3/ha. Aspen, Jackpine and White spruce stands range in productivity from a low of approximately 15 m^3/ha to 230 m^3/ha for aspen, 318 m^3/ha for Jackpine and 308 m^3/ha for white spruce. The greatest volumes occur within Jack pine - White spruce stands and Aspen - White spruce stands (354 m^3/ha and 323 m^3/ha, respectively).

Average mean annual increment (MAI) for deciduous timber is estimated to be 3.10 m^3/ha/A (Hardy Associates and Silva Consulting 1981). Black spruce forest types had an average MAI of 1.69 m^3/ha/A and jack pine stands had an average MAI of 2.88 m^3/ha/A. Based on information collected by Reid and Sherstabetoff (1984) the estimated MAI for white spruce is 3.47 m^3/ha/A.

Within the Local Study Area, the total volume of merchantable timber is estimated to be 363 710 m^3 (includes all timber types with ≥50 m^3/ha at the 15 cm stump and 11 cm top diameters utilization standard). Within the mine and plant sites, merchantable volume is approximately 6500 m^3 (1% of the Local Study Area). Merchantable forests comprise approximately 49% of the Local Study Area. Productive forests include single species and mixed species stands of jack pine, white spruce, aspen and black spruce. Timber stands with heights less than 12 m were generally not merchantable, regardless of species present.

4.9.3 *Consumptive Resource Use*

The capabilities of the BCESA to support game species of wildlife (with the exception of moose, coyote, black bear, hare, red squirrel and beaver) and sportsfish are low and, therefore, limit the amount of hunting, trapping and fishing that the area can sustain (Section 4.7).

Based on the Traditional Pursuits Study (Concord Environmental Corporation and RMC 1990), it is apparent that a significant portion of the families in Fort McKay, are still involved in resource harvesting activities, particularly hunting and trapping, and to a lesser extent fishing. These activities are a very important part of their lives.

Commercial resource uses outside of those listed above include aggregate extraction (11 ha), oil sand mining at the Bitumount Historic Site (2 ha) and the Bitumount airstrip.

Figure 4.34 Forest Capability for the Local Study Area.

Hunting

Much of the hunting in the BCESA, both historically and presently, is native subsistence, primarily by the residents of Fort McKay. Within the Study Area, the Fort McKay First Nations has a reserve of 104 ha along the Athabasca River that the residents use for hunting. Hunting is important as a cultural activity, as well as providing a food source. The Traditional Pursuits Study shows there is less hunting by natives in the region now than historically due to the increase in availability of other types of work in the Fort McMurray-Fort McKay region (Concord Environmental Corporation and RMC 1990). However, hunting remains as an important part of traditional use in the proposed Solv-Ex Development Area (Fort McKay Environment Services Ltd. 1995).

All natives interviewed, hunt between September and November, inclusive (Concord Environmental Corporation and RMC 1990). Most individuals hunted from 1 to 60 days in 1988, with several or 30 days being the most common number of days spent hunting. Most of the natives indicated that from half to most of the meat eaten by their families comes from hunting and fishing.

Of the species identified as being hunted most commonly, the following were identified in decreasing order of frequency: hare, moose, ruffed grouse, spruce grouse and duck. Geese, sharp-tailed grouse, deer, ptarmigan, caribou and bear were identified by a small number of hunters as being hunted frequently (Concord Environmental Corporation and RMC 1990). Caribou were hunted historically, but no longer reside in the Study Area. Other species include loons, pelicans, swans, cranes, gulls, eagles and owls. All birds taken are used for meat, and feathers of eagles and owls are used for insulation and decorative purposes. Eggs of various bird species are also collected for food (Fort McKay Environment Services 1995; Appendix V). Upland game birds, such as grouse and ptarmigan, are found in the Study Area all year round and are hunted on an incidental basis throughout the year. Ptarmigan migrate through the Study Area from south to north in the spring and back in the fall. They are hunted on their southward migrations from about November to March (Fort McKay Environmental Services 1995).

All ungulates which are harvested by the people of the Community of Fort McKay are taken for meat, hides, horns, fat, tool-making materials, etc. These include moose, deer, caribou, and buffalo. Black bears, while under most circumstances considered a furbearer, are hunted as a big game animal for fat and fur from early spring to late fall (Fort McKay Environmental Services 1995; Appendix V).

Most hunters believe the amount of meat brought in by Fort McKay hunters has either decreased or stayed the same in amount. They believe that disturbance, the increase in numbers of hunters in the area and the wolf populations are reducing moose populations.

The concentration of hunting activity generally corresponded to the distribution of perceived importance of the site for hunting; that is, those sites perceived as the best sites were hunted most often by the individuals interviewed, and those perceived as the poor sites were hunted least often.

Wildlife Management Unit (WMU) 530 encompass the Biophysical Cumulative Effects Study Area east of the Athabasca River. The hunting seasons for this WMU are listed in Table 4.27.

Alberta Fish and Wildlife compiled information on the harvest and hunting efforts by big game hunters in Alberta for the 1986, 1987 and 1988 hunting seasons (Alberta Fish and Wildlife 1987, 1988, 1989*b*). Table 4.27 summarizes this information for Wildlife Management Unit 530. This Management Unit supported between 0.2 to 0.4% of the moose, 0.1% of the white-tailed deer and 0 to 0.1% of the black bear harvested in Alberta. They also supported 0.3 to 0.9% of the moose hunter days, 0.1 to 0.6% of the white-tailed deer hunter days, 0 to 0.1% of the mule deer hunter days and 0.3 to 0.8% of the black bear hunter days in the province. This compares to latest information available (1992) on hunting seasons (Alberta Fish and Wildlife 1994) where 0.5% of the moose, 0.05% of the white-tailed deer and 3.9% of the black bears harvested in Alberta were taken from WMU 530 (Table 4.28). The 1992 hunting season accounted for 0.6 % of the moose hunter day, 0.1% of the white-tailed deer hunter days and 0.9% of the black bear hunter days. These values do not include hunting activities by native hunters.

Trapping

Eight registered traplines are within the boundaries of the BCESA and three are within the LSA (Figure 4.35). The fur harvests for the trapline within the LSA, from 1983 to 1993, are summarized in Table 4.29. The annual harvest levels vary from an average of 140 to 13 animals. Beavers are the most abundantly harvested animals on two of the traplines while squirrels are the most abundant on the third (beavers being second in abundance).

The Traditional Pursuits Study shows that there is less trapping activity by natives in the region now than historically; one of the reasons for this change is the increase in availability of other types of work in the Fort McMurray-Fort McKay region (Concord Environmental Corporation and RMC 1990). In addition, there has been a reduction in fur prices as a result of reduced sales of fur products (Fort McKay Environment Services Ltd. 1995).

Most trappers (e.g., 24 out of 27) spent either several days, or between 30 to 100 days working their trapline in the 1988-89 season. The busiest trapping months were from November to February and April to May (exclusively for muskrat), with most trapping concentrated in December and January.

Most traplines are set in either aspen, balsam poplar or shrub habitats, while some lines run through marsh and meadow habitats. Most trappers set up to an average of 50 traps in their trapping area, although several individuals set up to 150 traps. In addition, all trappers set snares on their traplines.

Both sides of the Athabasca are exploited for furbearers. Of the species identified as being trapped most commonly, the following were identified in decreasing order of frequency: hare, beaver, squirrel, weasel, fisher, mink and lynx. Fox, wolf, muskrat, coyote and otter, and marten were identified by a small number of trappers as being trapped frequently, and wolverine was trapped in low numbers. Black bears are trapped occasionally (Fort McKay Environment Services Ltd. 1995). These animals are used for food and a wide variety of products required in daily life.

Table 4.27 Hunting seasons within Wildlife Management Unit 530.

Game Species	Hunting Season	Class of Animal
Archery Season		
White-tailed Deer	Aug. 22 - Sept. 4	antlered or antlerless
Mule Deer	Aug. 22 - Sept. 4	antlered
Moose	Aug. 22 - Sept. 4	antlered
Black Bear	Aug. 22 - Sept. 4	
General Season		
White-tailed Deer	Sept. 5 - Nov. 26 Oct. 31 - Nov. 26	antlered
Mule Deer	Sept. 5 - Nov. 26	antlered or antlered
Moose	Sept. 5 - Oct. 9	antlered
Elk	Oct. 1 - Nov. 26	antlered
Black Bear	Sept. 5 - Nov. 26 Apr. 15 - Jul. 15	
Game Birds		
Ruffed and Spruce Grouse	Sept. 1 - Nov. 30	
Sharp-tailed Grouse	Sept. 1 - Nov. 30	
Ptarmigan	Sept. 1 - Dec. 15	
Duck, Coots and Common Snipe	Sept. 1 - Dec. 16	
White-fronted and Canada Goose	Sept. 1 - Dec. 16	
Snow and Ross' Geese	Sept. 1 - Dec. 16	

Table 4.28 Big game harvest for Wildlife Management Unit 530.

Species	Animals Harvested		Number of Hunter Days	
	Estimated Number	% of Provincial Harvest	Estimated Number	% of Provincial Total
Moose				
1986	56	0.4	3732	0.9
1987	24	0.2	1092	0.2
1988	27	0.2	1154	0.3
1992	42	0.5	1285	0.6
White-Tailed Deer				
1986	17	0.1	3099	0.6
1987	6	0.1	1122	0.2
1988	6	0.1	689	0.1
1992	12	0.1	408	0.1
Black Bear				
1986	0	0	341	0.8
1987	12	0.7	244	0.3
1988	0	0	57	0.3
1992	27	3.9	124	0.9

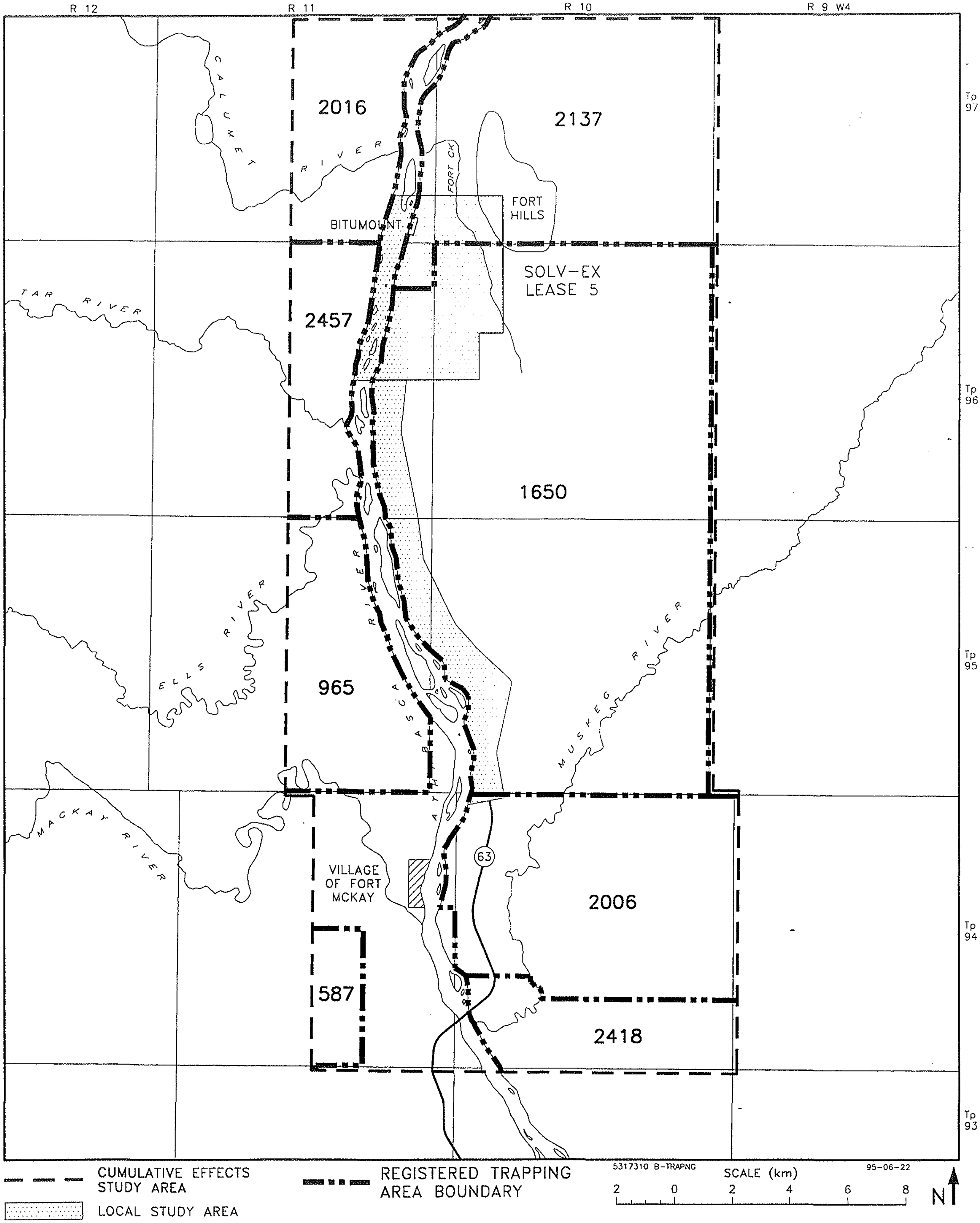


FIGURE 4.35 REGISTERED TRAPPING AREAS

Table 4.29 Average Annual Trapline Fur Harvest for 1983 to 1993 inclusive.

Registered Trapping Area (RTA)	Beaver	Coyote	Weasel	Fisher	Cross Fox	Red Fox	Lynx	Marten	Muskrat	Otter	Squirrel	Wolverine	Mink	Timber Wolf
2006	19.5	0.3	6.1	3.2	0.2	0.7	3.0	0.2	6.3	0.3	5.0	0.1	0.3	0
1650	5.6	0.1	0.6	0.3	0	0	0	0.1	2.0	0	3.3	0	1.4	0
2137	25.8	0.4	5.0	1.1	0.1	0.3	0.9	1.1	7.8	0.1	92.4	0	1.5	3.5

Over half the trappers believe there has been a decrease in the number of furbearers trapped by Fort McKay people, while one-third of the individuals believe the number of furbearers trapped is unchanged. The decrease in furbearer numbers has been attributed to increased disturbance and habitat clearing in the area (Concord Scientific and RMC 1990 and Fort McKay Environment Services Ltd. 1995).

Fishing

Within the BCESA, the Athabasca River and its tributary the Muskeg River support fish that are utilized by man. The Athabasca contains Arctic grayling, lake whitefish, northern pike, yellow perch, goldeye and walleye, which are important domestic, commercial and sports fisheries. The lower reaches of the Muskeg support lake white fish, walleye, Arctic grayling and northern pike, while the middle reaches support northern pike (feeding excursions) and Arctic grayling (spawning).

Native fishing activities were evaluated during the Traditional Pursuits Study (Concord Environmental Corporation and RMC 1990) and by Fort McKay Environmental Services (1995; Appendix VIII). The most frequently fished month was September followed by June, July and August. The number of days spent fishing by individuals in 1988 ranged widely from 2 to 150 days, although most fishermen spent between 14 and 30 days fishing.

The species of fish identified as being utilized by Fort McKay are jackfish, whitefish, pickerel, lake trout, goldeye, ling, sucker, chub and perch. Fish were taken, not only for food but also for feed for dogs used, and in use, for traplines. Although the timing of exploitation of specific species varied according to migration and availability cycles, fish camps often formed the basis for other social and cultural events and transactions (Fort McKay Environmental Services Ltd. 1995; Appendix VIII).

Most fishermen believe there has been a decrease in the number of fish caught by fishermen from Fort McKay. Portions of the Athabasca River, or its associated lakes such as Saline were identified, as good fishing sites. Historically, fish were taken in numbers from the Athabasca River. This practice has not occurred for many years because of the warnings issued by the Alberta Fish and Wildlife Service to the effect that individuals should ration the amount of Athabasca River fish they eat in a specified period of time because they contain contaminants, such as heavy metals and chlorinated hydrocarbons. While a certain number of large predatory fish, such as jackfish, pickerel and ling, are still taken from the river and eaten from time to time, the bulk of the fish consumed by the people of Fort McKay are taken from the lakes and tributary streams in the area (Fort McKay Environmental Services 1995; Appendix VIII).

Individuals were asked to identify the main areas in which they fished in the region. In general, sites where fishing is concentrated are perceived to be the best sites. The Athabasca River (especially the confluences with the Muskeg River, Firebag River, Dover River and several other tributaries) were identified as the main fishing sites.

Aggregate Resources

The Local Study Area includes several deposits of gravel which are relatively scarce in this region. The location and extent of these deposits is illustrated on Figure 2.2. There are two active gravel pits located in the Local Study Area. One is adjacent to the northern end of the Bitumount airstrip and the second is located at the southern end of the Local Study Area.

The Fort McMurray-Athabasca Oil Sands Subregional IRP (1994) provides guidelines for the management of aggregate resources within the Mildred-Kearl Lakes RMA. These guidelines request that all aggregate resources discovered during exploration or development activities, that are not used during mineral development, be stockpiled. Furthermore, it is an objective to recover aggregate resources during mining and processing operations.

4.9.4 *Non-consumptive Resource Use*

Fort McKay First Nations has identified several traditional uses within the BCESA. These include the traditional uses of cabins and trails for trapping and hunting, berry picking and the use of native plants for medicinal, dietary and other uses. There are six cabins within the Cumulative Effects Study Area and four within the Local Study Area which are owned by Felix Beaver, Pat Shott, Isadore Lacorde and Louis Tourangeau (Fort McKay Environment Services Ltd. 1995; Appendix VIII). In the Local Study Area two cabins are located near the Bitumount historic site and 2 others are located near Isadore's Lake (Fort McKay Environment Services Ltd. 1995). The Shott and Lacorde cabins are associated with burial sites. In addition, to the north of the Local Study Area is a graveyard containing over 40 graves. Trails in this area consist of recent clearings and hand cleared lines that have been marked and maintained for several generations (Fort McKay Environment Services Ltd. 1995). Berry picking in the area includes raspberries, cranberries and kinnikinnick. Plant collection and use includes not only edible foods such as berries but also those used for building materials and medicinal and herbal purposes. Berry picking was a family activity and conducted on a year round basis. Some 25 types of berries occur in a variety of habitats in the study area. Specific locales used by band members for acquisition of medicinally related flora focus on the Athabasca River and its tributaries (Fort McKay Environmental Services Ltd. 1995). Traditional use of native plants is outlined in Table 4.30. Plant species with traditional uses that are located within the Local and Cumulative Effects Study Area are listed in Table 4.31. The plant communities in which the plants listed in Table 4.30 can be found are discussed in Section 4.6.

According to the Alberta Land Inventory capability maps for recreation (ALI 1977), the BCESA has moderately low (Class 5) to very low (Class 7) capability for outdoor recreation. This site lacks the natural quality and significant features to rate a higher classification, but has natural capability to generate and sustain low annual use based on dispersed activities. In general, the Study Area provides potential for use in viewing and hunting of upland wildlife. The Athabasca River is rated as having moderate to moderately high capability (Classes 3 and 4).

The Local Study Area includes a portion of the proposed Fort Hills Recreation Area (Figure 2.2). This recreation area was proposed to accommodate the needs of the residents of the town that would have been built had the Alsands project proceeded. There are no immediate plans to develop this recreation site.

Table 4.30 Traditional Uses of Vascular Plants by the Cree.

Botanical Name	Common Name	Traditional Uses				
		Medicinal	Dietary	Ritual	Utensil	Dyes
VASCULAR PLANTS						
Abies balsamifera	Balsam fir	x[c]				
Achillea millefolium	Common yarrow	x[b]				
Alnus crispa	Green alder	x[b,c]			x[a]	x[b]
Alnus tenufolia	River alder	x[b,c]			x[a]	x[b]
Amelanchier alnifolia	Saskatoon	x[b]	x[a,b]		x[a]	
Aralia nudicaulis	Wild sarsaparilla	x[a]				
Arctostaphylos uva-ursi	Common bearberry	x[a]		x[a]		x[b]
Aster conspicuus	Showy aster	x[b]		x[b]		
Betula papyrifera	Paper birch	x[a]	x[a]	x[a]	x[a]	x[b]
Betula pumila	Bog birch	x[b]	x[a]			
Companula rotundifolia	Harebell	x[a]				
Cornus stolonifera	Red-osier dogwood	x[a]		x[a,b]		x[a]
Equisetum spp.	Horsetail	x[a]			x[a]	
Fragaria virginiana	Wild strawberry	x[a,b]	x[a,b]			
Galium boreale	Northern bedstraw					x[a]
Galium trifolium	Sweet-scented bedstraw			x[a]	x[a]	
Juniperus commnunis	Ground juniper	x[a,b]				
Larix laricina	Tamarack	x[b,c]				
Ledum groenlandicum	Labrador tea	x[a,b]	x[a]			
Lonicera caerulea	Fly honeysuckle	x[b]				
Lonicera dioica var. glaucescens	Twining honeysuckle	x[b]				
Lonicera involucrata	Bracted honeysuckle	x[b]				
Lycopodium annotinum	Stiff club moss			x[a]		
Mentha arvensis	Wild mint	x[a,b,c]	x[b]			
Picea glauca	White spruce	x[a,c]			x[a]	
Picea mariana	Black spruce	x[c]				

Table 4.30 Continued.

Botanical Name	Common Name	Traditional Uses				
		Medicinal	Dietary	Ritual	Utensil	Dyes
VASCULAR PLANTS (Concluded)						
Pinus contorta var. latifolia	Lodgepole pine	x[c]				
Pinus banksiana	Jack pine	x[c]			x[b]	
Plantago major	Common plaintain	x[a]				
Polygala senega	Seneca-root	x[c]				
Populus balsamifera	Balsam poplar	x[a,b,c]			x[a]	
Populus tremuloides	Trembling aspen	x[a,b,c]			x[a]	
Prunus pennsylvanica	Pincherry		x[b]			
Prunus virginiana	Chokecherry	x[a,b]	x[a]			
Pyrola asarifolia	Common pink wintergreen	x[b,c]				
Pyrola elliptica	White wintergreen	x[b,c]				
Ribes hudsonianum	Wild black currant	x[a]	x[a]			
Rosa acicularis	Prickly rose	x[a]				
Rubus chamaemorus	Cloudberry	x[a]	x[b]			
Rubus idaeus	Wild red raspberry	x[b]	x[b]			
Rubus pubescens	Dewberry	x[b]	x[b]			
Rumex occidentalis	Western dock					x[b]
Salix spp.	Willow	x[a,c]		x[a]	x[a]	
Scirpus spp.	Bulrush		x[b]			
Symphoricarpos albus	Snowberry	x[a]				
Typha latifolia	Common cattail		x[a,b]			
Urtica dioica ssp. gracilis	Common nettle	x[b]	x[b]			
Vaccinium myrtilloides	Blueberry	x[b,c]	x[b]			
Vaccinium vitis-idaea	Bog cranberry		x[b]			
Viburnum edule	Low-bush cranberry	x[b]				
Viburnum opolus	High-bush cranberry	x[b]				

Table 4.30 Concluded.

Botanical Name	Common Name	Traditional Uses				
		Medicinal	Dietary	Ritual	Utensil	Dyes
FUNGI, LICHENS AND MOSSES						
Fomes officinalis	Bracket fungus	x[a]			x[b]	
Fomes pinicola	Bracket fungus	x[a]			x[b]	
Polyporus tuberaster	Canadian tuckahoe fungus	x[a]				
Lycoperdon spp.	Puffball	x[a,b]				
Echinodontium tinctorium	Red touchwood fungus	x[a]				
Umbilicaria spp.	Rock tripe		x[a]			
Sphagnum spp.	Sphagnum moss				x[a]	

Sources:

(a) Kerick, J. 1982. Living with the Land: Use of plants by the native people of Alberta. Alberta Culture. 39 pp.

(b) Paton, J. (Ed.). 1980. Some native herbal remedies. Friends of the Devonian Botanic Garden. Publication No. 8A.

(c) Fort McKay Environment Services Ltd. 1995. Information report for Solv-ex Cumulative Effects Study. Fort McMurray.

Table 4.31 Traditional plants located within the Local and Cumulative Effects Study Areas.

Plant Species	Location	
	Local Study Area	Cumulative Effects Study Area
Cranberry	x	x
Chokecherry		x
Balsam fir		x
Birch	x	
Blueberry		x
Hazelnut		x
Jack pine	x	x
Kinnikinnick	x	x
Mint (medicinal)	x	
Muskeg moss (medicinal)		x
Pincherry		x
Raspberry		x
Rat root (medicinal)		x
Tamarack		x
Willow	x	x

Source: Fort McKay Environmental Services Ltd. (1995).

Based on Phillips *et al.* (1978*a*), non-consumptive resource use in the Fort McMurray area include, in decreasing order of frequency: driving for pleasure, camping, picnicking, hiking, snowmobiling, exploring, cross-country skiing and boating. These activities within the Local Study Area are currently limited by restricted access to the site. Other activities likely include: berry-picking, photography and bird-watching.

Phillips *et al.* (1978*a*) assessed the non-consumptive resource activities in the Regional Study Area during 1975-1976. An estimated 50 170 Albertans (3.6% of provincial total) engaged in non-consumptive fish and wildlife use in the Regional Study Area, for a total of 83 390 recreation days (0.5% of provincial total). In light of the increase in the population of Fort McMurray since 1975, the overall number of recreation days in the region has probably increased commensurably.

Non-consumptive recreational fish and wildlife activities of Study Area residents were limited to comparatively few accessible locations. These locations included: Fort McMurray, Gregoire Lake, Anzac, Fort McKay and areas along the Athabasca River (Phillips *et al.* 1978*a*).

Non-consumptive recreational use of fish and wildlife through observations and study generally takes place in association with other outdoor recreation activities. Study Area residents undertook, in order of frequency, the following non-consumptive fish and wildlife use activities: driving for pleasure, camping, picnicking, hiking, snowmobiling, exploring, cross-country skiing and boating. Active camp residents (i.e., Syncrude and Suncor camps) included camping, driving for pleasure, hiking and exploring as activities associated with their non-consumptive fish and wildlife enjoyment.

Individuals typically engaged in more than one recreational activity during any given outing (e.g., driving for pleasure, picnicking, camping, fishing and hiking may all be part of a single family outing). Considerable non-consumptive recreational fish and wildlife activity took place in association with consumptive activity; approximately 27% of Study Area residents engaged in fishing.

Non-consumptive resource users liked to see, in order of preference, the following animals: bear, deer, moose, squirrel, wolf, beaver, lynx, rabbit, chipmunk, caribou, fox, coyote, elk, duck, trout and geese.

The annual total dollar benefit from non-consumptive activities in the AOSERP Study Area in 1975-1976 was $250 180 for Alberta residents, and slightly less for Study Area residents at $209 087 (in 1975-1976 dollars).

4.9.5 *Agriculture*

There are no agricultural activities within or in the vicinity of the BCESA.

Agricultural capabilities in the region are primarily limited by the short, cool growing season, although too much or too little soil moisture and a deficiency of plant nutrients in the soil also restrict plant growth. The soil capability for agriculture is described under Section 4.3.2.

4.9.6 *Bitumount Airstrip*

The Bitumount airstrip is a small airstrip that is used as a staging area for fire control purposes by the Alberta Forest Service. This airstrip receives limited use and is not considered to be essential for fire control purposes (Chris Hale, Land Use Officer, pers. comm.).

5.0 BIOPHYSICAL RESOURCES IMPACT ASSESSMENT

5.1 Approach and Methodology Used for Impact Evaluation

Matrices summarizing the impact ratings for the potential effects of the Solv-Ex Experimental Co-production project on biophysical (air, water and aquatic resources, terrestrial resources, resource use), historical and socio-economic resources, during the Life of the Operation and Post-Operation phases, are summarized in Table 5.1.

This section describes the assessment methodology used to identify and classify environmental impacts attributed to the Solv-Ex project. The methodology includes: the formulation of an impact hypothesis for each biophysical or historical resource and presentation of the hypothesis in a schematic diagram; a discussion of the impacts identified in the schematic hypotheses; recommendations of mitigation, enhancement on compensation measures; rating the Degree of Concern of each residual impact; and a discussion on potential monitoring and research programs. The section on air does not follow the above described format, as it has been written to conform with requirements outlined by Alberta Environmental Protection in the Draft 1994 Air Quality Model Guidelines.

- Impact hypotheses were prepared to describe the pathways through which project activities may affect aquatic and terrestrial environmental resources, historical resources and resource use. Each hypothesis starts with the project activity (or group of activities) and, through one or more impact pathways (comprised of several links) defines a specific effect on an environmental or historical resource or resource use. Impacts were described as those that would occur during the operational life, i.e., up to the year 2002 and those that would extend beyond the operation, i.e., beyond the year 2002. Wherever applicable, the cumulative effects of other developments that are affecting the same environmental resources as are being affected by the Solv-Ex project have been discussed in these hypotheses, i.e., air, surface water, vegetation, habitat and resource use.

- Each potential impact of the Solv-Ex project has been discussed in light of our understanding of project activities, and a review of the scientific literature. An important aspect of the assessment process was the attempt to quantify the impacts as much as possible.

- Mitigation, enhancement and/or compensation measures have been recommended to reduce or minimize potential impacts. Reclamation is considered an important form of mitigation. Residual impacts are the effects that remain after mitigation, enhancement and compensation measures have been implemented.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project.

A. AIR QUALITY

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Increased Ambient SO_2 Concentrations Deposition of Acid-Forming Compounds	• SO_2 emissions associated with normal Phase I and II operations are expected to be about 1.47 and 9.82 t/d, respectively. • A sulphur recovery plant with a long-term recovery efficiency of 98% will reduce SO_2 emissions. • A normal 99% SO_2/SO_3 converter in the acid plant will reduce SO_2 emissions. • The sour water stripper overhead is directed to the sulphur recovery plant to reduce SO_2 emissions. • Acid plant scrubber stream will be combined with sulphur recovery incinerator exhaust streams and vented through a common stack to increase plume rise. • Prudent operatorship and maintenance procedures will help minimize the flaring of sour gas streams.	**Life of Operation:** • Maximum SO_2 concentrations as a one-hour average are expected to be in the 126 to 419 $\mu g/m^3$ range. The corresponding guideline for SO_2 is 450 $\mu g/m^3$. These maximum values are predicted to occur within 4 km of the plant. • Maximum daily average SO_2 concentrations are expected to be in the 74 to 106 $\mu g/m^3$ range. This compares to the guideline value of 150 $\mu g/m^3$ of SO_2. • Maximum annual average SO_2 concentrations are expected to be in the 3.4 to 7.0 $\mu g/m^3$ range. This is below the 30 $\mu g/m^3$ guideline for SO_2. • Because of the Suncor SO_2 reduction program, the background maximum total deposition in the region is expected to be 9.9 kg/SO_4^{-2}/ha/a (EA = 0.28 kmol H^+/ha/a). In the vicinity of the plant, the background maximum EA is 0.15 kmol H^+/ha/a. • The operation of the Solv-Ex facility will increase the background level in the vicinity of the plant by up to 3.13 kg/SO_4^{-2}/ha/a (EA = 0.14 kmol H^+/ha/a). The EA in the vicinity of the Solv-Ex plant (under Suncor's reduction program) is 0.20 kmol H^+/ha/a.
2. Increased Ambient NO_x Concentrations	• NO_x emissions associated with Phase II operations are expected to be about 0.65 t/d and 1.06 t/d for the diesel oil and natural gas combustion alternatives.	**Life of Operation:** • The maximum one-hour average NO_2 concentrations resulting from the proposed Solv-Ex Operation is about 95 $\mu g/m^3$. This value is predicted to occur on the plant site and is below the 400 $\mu g/m^3$ guideline for NO_2.
3. Increased Particulate Concentrations	• Particulate emissions from stationary sources are expected to be 0.74 t/d and 0.88 t/d from the natural gas and diesel oil combustion alternative. • The double salt dryer, $FeSO_4$ dryer and K_2SO_4 dryer are equipped with bag filters and/or wet scrubbers to reduce particulate emissions. • Venturi scrubber servicing the clay dryer, agglomerator and cure drum will reduce particulate emissions.	**Life of Operation:** • The maximum daily average particulate combustion resulting from the proposed Solv-Ex operation is 97 $\mu g/m^3$ with screening meteorology. SandAlta meteorology prediction is 50 $\mu g/m^3$. This is less than the 100 $\mu g/m^3$ TSP guideline.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

A. AIR QUALITY (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
4. Increased CO_2 Emissions	• Stationary and mobile CO_2 emissions are expected to be up to 357 and 1162 t/d for Phase I and Phase II, respectively. Energy utilization practices to increase efficiency and reduce CO_2 emission include: - waste heat recovery exchangers - concurrent power and steam generation (co-generation) - internal recycle of process water.	**Life of Operation: (Continued)** • CO_2 emissions released from Solv-Ex are estimated to be 1162 t/d. CO_2 emissions have been related to global scale climate changes.
5. Increased Noise Levels	• Processes and equipment generating noise will be put in buildings or enclosed to attenuate noise levels. • There are no engine-driven compressors.	**Life of Operation:** • Off-site noise levels beyond 1.5 km will meet the AEUB guideline of 40 dBA Leq.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

B. WATER AND AQUATIC RESOURCES

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Surface Water Flows and Quality (Figure 5.13)	• A buffer zone of undisturbed land and vegetation will be retained along the Athabasca River to prevent erosion and sedimentation. • Sediment control ponds (including end-pit lake during abandonment phase) will be used to reduce sedimentation in the Athabasca River. • No effluent will be released to the Athabasca River unless it meets AEP's Surface Water Quality Objectives. • A gated culvert in Highway 63 will be designed so it can be shut-off to contain potential spills. • A water licence from AEP will be required for water withdrawals from the Athabasca River. • Plant site runoff will be collected and recycled into the plant operation to the fullest extent, to minimize water withdrawal from the Athabasca. • The following surface water monitoring program will be undertaken: - Water withdrawals from the Athabasca will be monitored and recorded at the pumphouse at the Athabasca River, - The total flow returned to the Athabasca River via the small drainage at the plant site will be monitored at the gated culvert at Highway 63, - If the dewatering from the mine is discharged directly into the Athabasca River, the rate will be monitored at the pumps in the mine, - Releases from on-site ponds will be monitored in accordance with AEP regulations, and - During any plant upset conditions which result in releases to the external environment, water quality will be continuously monitored as deemed necessary until normal operations are resumed.	**Life of Operation:** • Withdrawal of water from the Athabasca River, for plant make-up will reach a maximum of 5.0 Mm^3 per year and will require a Licence under the Water Resources Act. There could be up to a maximum 0.2% decrease in Athabasca River flows during the lowest recorded flow month, if this occurred coincident with startup, due to these withdrawals. This impact is considered Low in magnitude, Negative, Moderate-term in duration, Regional in geographic extent, Continuous and Irreversible during the operations phase. • The potential for exchange of water between the mine and the Athabasca River has not yet been determined. Geotechnical investigations through drilling in 1995 will be used to evaluate this potential impact, and potential effects on the flow or quality of the river. If necessary, Solv-Ex will engineer mitigation to minimize water flow into the mine, and thus ensure pit integrity and worker safety (Undetermined Impact). **Post-Operation:** • Surface drainage will be re-established in the Development Area through the re-development of portions of original streams, and the development of a new end-pit lake. This impact is considered Low in magnitude, Positive, Long-term in duration and Regional in geographic extent.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

B. WATER AND AQUATIC RESOURCES (Continued).

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
2. Changes in Groundwater Flows and Quality (Figures 5.17 and 5.18)	• To *minimize* the potential for seepage of contaminants from storage or process areas in the plant site area, storage areas will be lined wherever feasible (e.g., hydrocarbon tank, sulphur and pitch, storage areas). In addition surface and subsurface drainage will be collected and routed to the lined drainage retention ponds. • If a landfill is constructed, it will be designed to AEP standards. • Solv-Ex will join the Area "Y" Environmental Co-operative which will make the oil spill containment and clean-up resources of the Co-operative available to handle any emergencies. • Monitoring wells will be installed at the Lease area to monitor potential impacts on the underlying groundwater quality and changes in groundwater levels. The monitoring program will be designed to meet the requirements outlined in the Clean Water Licence to Operate.	**Life of Operation:** • In the vicinity of the mine and plantsite, there will be a reduction in groundwater levels in the shallow and the upper Cretaceous aquifers. This impact is considered Moderate in magnitude, as the water level will be reduced to the mine base, Negative, Long-term, Continuous, Local in spatial extent and Irreversible during the mining operation. • There will be a reduction in groundwater levels in the basal aquifer, where present, if mine depressurization is required. This impact is considered High in magnitude, Negative, Long-term, Local, Continuous during mining activities, and Irreversible as oil sand is replaced with wash sand. • If seepage of hydrocarbons from the hydrocarbon tank area or the tailings disposal area occur, groundwater quality may be impacted in a limited area. This impact is considered Low to Moderate in magnitude, Negative only if seepage occurs, Short-term if seepage is identified and mitigated, Continuous, Local, and Reversible if seepage is identified and mitigated. **Post-Operation:** • As drainage patterns are re-established and the end-pit lake is filled, groundwater tables in the mine and plant site areas will be restored to pre-development levels, except in the vicinity of the end-pit lake and mined area where the water table is expected to stabilize at lower than pre-disturbance levels. This impact is considered Positive and Long-term (other impacts terms are not applicable).

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

B. WATER AND AQUATIC RESOURCES (Concluded).

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
3. Change in Fish Habitat and Populations (Figure 5.23)	• Avoidance of Fort Creek. • Sediment control ponds and buffer zones along the Athabasca River will be used to reduce sediment levels entering the Athabasca River. • Ensure all water discharged to the river meets Alberta Environmental Protection standards. • Screen water intake to minimize the entrainment of fish from the Athabasca River. • Restore/stabilize Athabasca River banks and establish end-pit lake. The potential productivity and suitability of the end-pit lake for fish should be examined prior to abandonment. • Baseline biophysical data on water quality, fish use, aquatic habitat and macrovertebrate fauna of Fort Creek should be collected because of its association with the Solv-Ex lease and project area.	**Life of Operation:** • Additions of sediment from construction activities and surface drainage to the Athabasca River may decrease local aquatic habitat capability and biota. This impact would be Low in magnitude, Negative, Short-term in duration, Continuous during the construction phase, Local in geographic extent and Reversible. • Additional people associated with the project and improved access along Highway 63 will result in increased fishing pressure and harvest and a decrease fish populations. This impact would be Low in magnitude, Negative, Long-term in duration, Regional in geographic extent and Reversible if populations are not too heavily fished. • Bank protection/stabilization association with the water intake and the shoreline in the vicinity of the mine along the Athabasca River will result in additional aquatic habitat and increased diversity. This impact would be Low in magnitude, Positive, Long-term in duration, Continuous, Local in extent and Reversible. **Post-Operation:** • Development of an end-pit lake at abandonment will create new aquatic habitat. Restoration/stabilization of river banks and possible local stream enhancement may increase fish and aquatic habitat. Habitat restoration and enhancement would be Positive, Long-term, Continuous and Local (other impact terms are not applicable). • Continued increase in fishing pressure may result due to improved access. Although this impact is Negative, it would be Low in magnitude, Long-term and Regional (other impact terms are not applicable).

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Landforms (Figure 5.19)	• Approximately 317 ha out of the 331 ha of disturbed land will be reclaimed to landforms compatible with the surrounding environment and to meet AEP reclamation guidelines. • Potential for erosion of recontoured disposal areas will be reduced by revegetating disturbed areas as soon as possible.	**Life of Operation:** • There will be a progressive disturbance of 331 ha of landforms during the 7 year operating period of the Solv-Ex project. During operation, reclamation will have been initiated on 20 ha of the mine to re-establish landforms. This disturbance represents 7% of the LSA (Moderate magnitude) and 0.6% of the CESA. • There will be a temporary disturbance of 67 ha of landforms during the 7 year operating period of the Solv-Ex project. The temporary impacts during operation will be Negative, Moderate in magnitude, Moderate in duration, Continuous, Local and Reversible. • There will be a permanent burial of 164 ha of landforms during the operation of the Solv-Ex project. These impacts will be Moderate in magnitude, Negative, Long-term, Once, Local and Irreversible. **Post-Operation:** • There will be a re-establishment of 137 ha of landforms (mine area, access roads, pipelines and plant sites that are similar to the pre-existing landforms). These impacts will be Positive, Moderate in magnitude, Long-term, Once, Local and Irreversible. • There will be 180 ha of new landforms created due to the end-pit lake and waste disposal areas. These impacts will be Moderate in magnitude, Neutral, Long-term in duration, Once, Local and Irreversible. • There will be a permanent loss of 14 ha due to the Highway 63 upgrade. These impacts will be Low in magnitude, Negative, Long-term, Once and Irreversible.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE) (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
2. Changes in Soil Capability (Figure 5.20)	• Progressive clearing of mine site will minimize exposure to erosion. • Sufficient "fair" and "better" organic mineral and sandy soils will be salvaged to meet reclamation needs. • Re-establish soil capability through reclamation. • Establish a monitoring program to examine the physical and chemical characteristics of reclaimed soils in the mine and other disturbed areas: - pH - Electrical conductivity - Saturation percentage - Sodium adsorption ratio - Particle size analyses - Soil structure - Reclamation suitability of horizons. On reconstructed soils, a detailed evaluation of the above parameters will be undertaken to aid in choosing appropriate vegetation seed mixes. Soil chemical and physical characteristics will be analyzed periodically to aid in judging reclamation success. Particular attention will be paid to evaluating soil tilth, as good soil chemistry (low SAR) is not always an assurance that soil physical properties will not limit reclamation success.	**Life of Operation:** • A total of 331 ha of soils will be disturbed during the 7 year operational phase of the Solv-Ex project. This represents a 7% increase in disturbance in the Local Study Area and 0.6% increase in the Biophysical Resource Cumulative Effect Study Area. Soil capabilities will be decreased through soil mixing and burial. Reclamation will restore 287 ha back to equivalent soil capabilities. There will be permanent loss of 44 ha of soils due to the Highway 63 upgrade and the end-pit lake. These residual impacts due to soil mixing and burial will be Moderate in magnitude, Negative, Moderate-term, Continuous, Local, Reversible and Irreversible. • Drainage of soils prior to site development will be required for the Organic and Glysolic soils. Drainage will improve the soil capability. **Post-Operation:** • Reclamation will restore soil capability on 287 ha of the disturbed areas. About 44 ha of soils will be permanently lost due to the Highway 63 upgrade and the end-pit lake. This residual impact will be Low to Moderate in magnitude, Negative, Long-term, Once, Local and Irreversible.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE) (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
3. Changes in Plant Vigor and Survival, and Vegetation Community Structure and Diversity (Figure 5.21)	• Clearing and reclamation of the mine site will be phased to reduce the size and area of vegetation disturbed at any one point in time. • Plant communities to be re-established on the 287 ha of reclaimed landscape are: aspen, mixedwood and coniferous (white spruce, jack pine and black spruce). Solv-Ex will consider re-establishing berry-producing shrubs. • Undertake forest fire suppression activities e.g., vegetation will be cleared to provide sufficient distances to limit the potential of fire escape from the Solv-Ex facilities. • A monitoring program will be designed to document the re-establishment of plant species and community types on reclaimed sites. Plots will be established to examine plant species composition.	**Life of Operation:** • There will be a loss of 331 ha (7%) of the vegetation communities within the Local Study Area as a result of site clearing. This will include black spruce (57%), fen (11%), aspen, (9%), aspen/jack pine (8%). This Moderate magnitude, Negative impact will be Local in spatial extent, Phased and Irreversible over the 7 year life of this project (Moderate duration). • The interactive effects of O_3 alone, and SO_2, NO_x and O_3 on plant growth and yield are difficult to predict due to the variability of responses amongst plant species and to various concentrations (Undetermined Impact). **Post-Operation:** • The 331 ha (7%) of the plant communities, within the Local Study Area, lost as a result of site clearing will partially be replaced following reclamation. A portion of the mine will be reclaimed to a 30 ha end-pit lake and 14 ha will be permanently removed due to paving of Highway 63. The remaining 287 ha will be reclaimed to vegetation communities; aspen (127 ha), mixedwood forest (123 ha) and coniferous forests of white spruce, jack pine and black spruce (37 ha). This will increase specific resource values such as aesthetics, timber productivity (400%) or wildlife, but will not completely return the site to the pre-construction species composition or community structure. The impacts will be Positive, Long-term in duration, Local in spatial extent, Moderate in magnitude, Phased and Irreversible, as the capability of the site and the plant species composition will be altered.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

C. TERRESTRIAL RESOURCES (TERRAIN, SOILS, VEGETATION AND WILDLIFE) (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
4. **Changes in Abundance of Terrestrial Wildlife (Figure 5.22)**	• Clearing and reclamation of the mine site will be phased to reduce the size of the area of habitat disturbed at any one point in time. • Solv-Ex will produce a "no net loss" of habitat policy for wildlife. The disturbed area will be reclaimed to a mosaic of habitat types: aspen forest, mixedwood and open black spruce forest. Other forms of habitat enhancement could be considered during reclamation. • A vegetated berm may be constructed along the west edge of the mine to minimize disruption to the wildlife movement corridor along the Athabasca River. • Have Alberta Fish and Wildlife remove nuisance species (e.g., bears, beaver) from the site. Implement a bear management plan if a landfill is eventually constructed. • Monitoring programs established to examine the composition and structure of vegetation types on reclaimed sites will be used to evaluate the quality and value of habitat for wildlife species. No monitoring programs to assess changes in wildlife population levels are recommended.	**Life of Operation:** • Within Lease 5, a total of 296 ha of habitat will be lost due to vegetation clearing and up to 927 ha due to habitat avoidance (worst case scenario). Within the Utility Corridor a total of 35 ha of habitat will be lost due to clearing, but there will be no increase in habitat loss due to alienation. Habitat loss is considered to be an impact Moderate to High in magnitude, Negative, Long-term in duration, Continuous (due to the phased nature of vegetation clearing and disturbance), Local to Regional in scope, and Irreversible during the Life of the Project. • There will be an increase in wildlife mortality due to wildlife-vehicle collisions as a result of increased traffic levels from the Solv-Ex project, on Highway 63. This impact is considered to be Low in magnitude, Negative, Moderate-term in duration, Continuous through the Life of the Project, Regional in Scope and Reversible if mortality rates remain low. • It is difficult to assess what portion of the moose or canid populations that use the Athabasca River as a movement corridor may be affected by barriers to movement created by development of the mine and other facilities. The construction of a vegetated berm along the west edge of the mine may mitigate this effect (Undetermined Impact). **Post-Operation:** • Over time site reclamation will replace the quality and capabilities of habitat that will be lost due to clearing of the Development Area. However, reclaimed habitat will not provide capability equivalent to pre-disturbance levels for several years after the end of project operation. After a few years, the successional vegetation will provide high quality habitat for species such as moose, bear and hare that depend on early to mid-successional habitat. This impact is considered Moderate in magnitude (7% of LSA), Positive, Long-term in duration, and Local to Regional in scope (other impact terms not applicable). • There may be a decrease in the populations of hunted wildlife species (e.g., moose, upland game birds) due to increased hunting pressures as a consequence of improved access along the upgraded Highway 63 and within the Development Area. This impact is expected to be Low to Moderate in magnitude, Negative, Local to Regional in scope and Long-term in duration (other impact terms not applicable).

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

D. RESOURCE USE

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Food Gathering Opportunities such as Berry Picking (Figure 5.24)	• The early successional vegetation stages will support berry producing shrubs. • No monitoring programs beyond those identified for soil and vegetation (Sections 5.5.2.4 and 5.6.5) are recommended.	**Life of Operation:** • The removal of 294 ha of vegetation that support edible plants and the restricted access to areas that were once accessible, will have a Moderate magnitude (7% of Local Study Area, or an increase of 1% in the Biophysical Cumulative Effects Study Area), Negative impact on traditional food gathering for the duration of the 7 year project. Access outside of this area along existing routes will be maintained. This impact is Irreversible within the life-span of the project (other impact terms are not applicable). **Post-Operation:** • Reclamation of the Development Area will return 287 ha (6% of the Local Study Area) to vegetation will increase the abundance of early to mid succession plants including strawberry, blueberry, chokecherry, rose Labrador tea, currant, cranberry and kinnikinnick. This will positively increase early successional edible plants for a period >7 years, however, the impact of the initial clearing is irreversible over the life of this project (Long-Term).
2. Changes in Timber Harvest Potential (Figure 5.25)	• Merchantable deciduous and coniferous timber will be salvaged during site clearing. • No monitoring programs beyond those identified for soil and vegetation (Sections 5.5.2.4 and 5.6.5) are recommended.	**Life of Operation:** • Approximately 296 ha of forest will be cleared within the Local Study Area. This will include 229 ha of non-merchantable and 67 ha or 6500 m^3 (2% in Local Study Area) of merchantable timber. An additional 355 m^3 of timber volume will be lost from the mine area. Merchantable wood will be salvaged. The disturbance will be phased and due to timber salvage, is classed as Low in magnitude, Negative, Irreversible, Long-term and Local in Scope. • The areas cleared for development will not be regenerated to productive forest during the life of the operation, except for 20 ha of the mine. This Moderate magnitude, Negative impact is a single occurrence with Long-term, Irreversible effects. **Post-Operation:** • Reclamation of the Lease 5 Development Area will return 287 ha of land to productive forest. Merchantable timber volumes will return in 50 years for aspen and between 80 and 100 years for coniferous species. Timber volume regeneration is predicted to have a 400% increase. This impact will be Positive, Moderate in magnitude, Long-term, and Local in Scope. The impacts are Irreversible for a period of greater than 10 years.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

D. RESOURCE USE (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
3. Changes in Fishing Opportunities (Figure 5.26)	• The end-pit lake will be designed to support sportfish, and could be stocked with sportfish. • No monitoring programs are recommended beyond those identified for fish resources (Sections 5.8.4).	**Life of Operation:** • None. **Post-Operation:** • There is expected to be an increase in fishing opportunities in the Local Study Area after reclamation primarily due to creation of the end-pit lake and improved access. This impact is considered Low in magnitude, Positive, Long-term in duration and Local in scope (other impact terms are not applicable).
4. Changes in Hunting and Trapping Opportunities (Figure 5.27)	• The site will be reclaimed to habitat that will support game species, e.g., moose, hare, beaver, etc. • The two trappers affected by the Solv-Ex development will be compensated for the loss of trapping opportunities. • No monitoring programs beyond those identified for wildlife in Section 5.7.5 are recommended.	**Life of Operation:** • There is expected to be a slight decrease in hunting and trapping opportunities in the vicinity of the Local Study Area due to the reduced abundance of terrestrial wildlife and secondarily to reduced access. This impact is considered Negative, Low in magnitude, Local to Regional in scope, Long-term in duration, and Irreversible. **Post-Operation:** • There is expected to be an increase in hunting and trapping opportunities due to the increased abundance of terrestrial game species, and possibly aquatic species, using the reclaimed Development Area. Improved access to the site will be available along Highway 63 and the upgraded winter road. This impact is considered Low in magnitude, Positive, Long-term in duration and Local in scope (other impact terms are not applicable).

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

D. RESOURCE USE (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
5. Changes in Non-Consumptive Resource Use (Figure 5.28)	• No monitoring programs beyond those recommended for vegetation (Section 5.6.5) are recommended.	**Life of Operation:** • Visual impacts will include the removal of 331 ha (7% of the Local Study Area) of forest cover and infrastructure development, mining activities, the development of overburden and tailings piles, and air emissions (including ice fog during the winter and sulphur dust during the first year of operation). To reduce visibility of the development from the Athabasca River, a berm/vegetation screen will be developed along the west edge of the mine. Solv-Ex facilities will be visible from the upgraded Highway 63 and upgraded winter road. This Irreversible, Negative impact will occur continuously during the life of the project (Moderate duration), and is considered Low to Moderate in magnitude (other impact terms are not applicable). • There will be some reduced opportunities for photography and wildlife viewing due to reduced numbers of wildlife and fish, and restricted access. This impact is considered Low in magnitude, due to the low non-consumptive use of site prior to development. These Irreversible, Negative impacts will occur continuously during the life of the project (Moderate duration; other impact terms are not applicable). **Post-Operation:** • The reclaimed landscape, increased abundance of wildlife and fish populations, and improved access will provide increased opportunities for non-consumptive resource use and improve aesthetics. This impact is considered Positive, Low to Moderate in magnitude, Long-term and Irreversible (other impact terms are not applicable). The Positive and visual impacts will be a Long-term duration. This impact is Irreversible and will be continuous.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

E. HISTORICAL RESOURCES

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. **Impacts on Historical Resources (Figure 7.1)**	• Conduct an Historic Resources Impact Assessment of all sites to be disturbed by the Solv-Ex Project.	**Life of Operation:** • Historic sites will occur on, or very near surface. These sites will be identified through the HRIA of the Solv-Ex Development Area. Mitigative activities to minimize the Primary impacts to historic sites include formal documentation/descriptive photography, mapping, artifact collection and/or controlled excavation to retrieve pertinent data on the site and activities. Archival research and documentation may be required. Solv-Ex's management plan to minimize effects on paleontological remains will ensure that the Royal Tyrell Museum of Paleontology is contacted and monitors any significant finds. With these mitigation procedures in place, this impact is considered Low to Moderate in magnitude, will be Negative, Long-term in duration, occur Once and be Irreversible during the life of the project. The scope of impact could occur at all three levels of geographic extent i.e., local, regional and provincial due to the importance of historic resource information. • Secondary impacts, which could adversely affect historical resources, include the unauthorized collection of specimens by non-archaeologists, and unregulated vehicular activity. Such potential adverse secondary impacts will be managed by restricting access to the Solv-Ex site by unauthorized individuals. The impact should be Low in magnitude, Negative and Long-term in duration (other impact terms are not applicable). • Bitumount is a provincially designated Historic Site. Solv-Ex development activities may visually impact the site, particularly in light of potential development of the site for tourism purposes. This impact is Negative, Moderate-term in duration and Irreversible during the life of the project (other impact terms are not applicable). • Positive effects from the HRIA and mitigation activities to historic and prehistoric and monitoring of paleontological finds will contribute to the scientific database and understanding of the history and prehistory of the region. This impact is considered Long-term in duration (other impact terms are not applicable). **Post-Operation:** • None.

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

F. SOCIO-ECONOMIC RESOURCES

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
1. Changes in Regional Labour Force Employment	• Maximize local and regional employment opportunities through planning and ongoing consultation with Canada Employment Centre and local Aboriginal employment/economic development officers.	**Life of Operation:** • There will be approximately 350 oil sands operations and maintenance positions available at the Solv-Ex facility north of Ft. McKay (Impact - high/positive/Ft. McKay) (Impact - low/positive/Ft. McMurray) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - moderate/negative/Ft. McKay) (Impact - low/negative/Ft. McMurray) (Impact - low/neutral/regional)
2. Changes in Regional Population	• Minimize local and population effects through use of on-site accommodations for construction and operations personnel.	**Life of Operation:** • It is estimated that the net population effect on Ft. McMurray during Solv-Ex operations is an increase of 400-500 persons (Impact - low/positive/Ft. McMurray) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/negative/Ft. McMurray) (Impact - low/neutral/regional)
3. Changes in Regional Business Opportunities	• Maximize local and regional business opportunities through award of supply/service contracts to Fort McKay, Fort McMurray and local Aboriginal companies.	**Life of Operation:** • Solv-Ex annual purchases during operations are estimated to be substantial (Impact - high/positive/Fort McKay) (Impact - moderate/positive/Fort McMurray) (Impact - minor/positive/regional) **Post-Operation:** • (Impact - moderate/negative/Fort McKay) (Impact - low/negative/Fort McMurray) (Impact - low/neutral/regional)

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

F. SOCIO-ECONOMIC RESOURCES (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
4. Changes in Regional Labour Force Training	• Maximize local and regional training opportunities through planning and ongoing consultation with Keyano College, Canada Employment Centre and local Aboriginal employment/ economic development officers.	**Life of Operation:** • Solv-Ex will work closely with Keyano College and other oil sands operators to identify and implement specific training needs, especially for local Aboriginals (Impact - moderate/positive/Ft. McKay) (Impact - low/positive/regional) **Post-Operation:** • (Impact - low/negative/Ft. McKay) (Impact - low/neutral/regional)
5. Changes in Regional Infrastructure	• Minimize local and regional infrastructure effects through use of existing facilities and construction of on-site permanent staff accommodations.	**Life of Operation:** • The use of an on-site camp for more than 50% of the operations worker accommodations will have low impact on regional infrastructure. Some available housing stock will be used in Ft. McMurray (Impact - low/neutral/regional) (Impact - moderate/positive/Ft. McMurray) **Post-Operation:** • (Impact - low/neutral/regional) (Impact - low/negative/Ft. McMurray)
6. Changes in Regional Transportation	• Minimize local and regional transportation effects through use of existing highway transportation network and utility corridors and upgrading of road network north of Ft. McKay to Solv-Ex site.	**Life of Operation:** • Increased traffic on Highway 63 and extension of daily highway use north of Ft. McKay to Solv-Ex site (Impact - moderate/negative/Ft. McKay) (Impact - low/negative/Ft. McMurray) **Post-Operation:** • (Impact - moderate/positive/Ft. McKay) (Impact - low/neutral/Ft. McMurray)

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Continued).

F. SOCIO-ECONOMIC RESOURCES (Continued)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
7. Changes in Regional Education - Primary and Secondary	• Minimize impacts on local and regional schools through on-site accommodations of personnel and planning and ongoing consultation with school superintendents.	**Life of Operation:** • Current over-capacity situation in Ft. McMurray school system (Impact - low/positive/Ft. McMurray) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/negative/Ft. McMurray) (Impact - low/neutral/regional)
8. Changes in Regional Education - Post-Secondary	• Maximize use of available job training resources at Canada Employment Centre and Keyano College for upgrading capabilities of local Aboriginals	**Life of Operation:** • Training for Solv-Ex operations and maintenance positions easily accommodated at Keyano College (Impact - low/positive/regional) **Post-Operation:** • (Impact - low/negative/regional)
9. Changes in Regional Public Health	• Minimize impacts on local and regional health and medical services through participation in regional Mutual Aid Program and ongoing consultation with local and regional health authorities	**Life of Operation:** • Health and medical requirements are easily accommodated within existing hospital and nursing station facilities (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/neutral/regional)
10. Changes in Regional Socio-Cultural Conditions	• Minimize impacts on Aboriginal communities through worker orientation/ cross-cultural programs and ongoing consultation with local Aboriginal community leaders	**Life of Operation:** • Oil sands projects are not new to Aboriginal communities in the study area but do bring change in lifestyle from traditional to industrial socio-economy (Impact - low/negative/Ft. McKay) (Impact - low/neutral/regional) **Post-Operation:** • (Impact - low/neutral/Ft. McKay) (Impact - low/neutral/regional)

Table 5.1 Summary of Residual Impacts of the Solv-Ex Experiment Co-production Project (Concluded).

F. SOCIO-ECONOMIC RESOURCES (Concluded)

Environmental Issue	Environmental Protection Plan Design Features/Mitigation/Monitoring	Residual Impact
11. Changes in Regional Substance-Abuse	• Minimize impacts on communities through worker orientation and ongoing consultation with community leaders, health authorities and law enforcement officials	**Life of Operation:** • Increase wage incomes in communities will likely lead to increase in consumption of alcohol and/or illegal drugs (Impact - moderate/negative/regional) **Post-Operation:** • (Impact - low/neutral/regional)
12. Changes in Regional Law Enforcement	• Minimize impacts on communities through worker orientation and ongoing consultation with law enforcement officials	**Life of Operation:** • Increase in wage incomes will likely lead to some increase in petty theft or impaired driving charges (Impact - low/negative/regional) **Post-Operation:** • (Impact - low/neutral/regional)

- Definitions of the terms used to rate the Degree of Concern of impacts are presented in Table 5.2. In addition to describing the nature of impact, the impact assessment methodology employs a rating system that indicates the magnitude, direction, duration, frequency, scope and reversibility of the expected effects. If an impact was considered minor, it was rated using only the term negligible.

- In light of the residual or undetermined impacts identified, monitoring and research programs were recommended to further evaluate impacts.

5.2 Air Quality and Noise

Two alternate fuel scenarios are under consideration which will result in different levels of impacts. Greater NO_x emissions are associated with the use of natural gas and greater SO_2 and particulate emissions are associated with the use of diesel oil. The following air quality assessment emphasizes the results for the worst case fuel use.

For the normal emission scenarios, hourly, daily and annual average concentrations were calculated. For upset emissions, only hourly concentrations were calculated as the duration of the upset is expected to be less than a day.

5.2.1 *Dispersion Modelling Approach*

Air quality simulation models provide a scientific means of relating industrial emissions to changes in ambient air quality. These models consist of mathematical equations to simulate transport, dispersion, transformation and deposition processes in the atmosphere. Models can address a wide range of spatial (short and long range) and temporal (one hour to annual) scales. Dispersion models can be classified according to the meteorological data they require. The following types of models were used for this assessment:

- **Screening.** These models calculate concentrations for a wide range of meteorological conditions. The conditions are either pre-selected by the model or user-defined. These models are primarily designed to determine maximum short-term (i.e., one-hour average) concentrations which usually occur within 10 km of the source.

- **Sequential Time Series.** These models are used to simulate air quality changes on an hour-by-hour basis using a representative year of hourly-average meteorological data (8760 h). These models create an hourly average concentration file for all source-receptor combinations. The hourly average concentration file can then be used to determine average concentrations for periods that are multiples of one hour (e.g., 24 h).

- **Climatological.** These models use summarized long-term meteorological data to calculate long-term (i.e., seasonal or annual) average concentrations and deposition. The summarized meteorological data are typically in the form of a joint frequency

Table 5.2 Terms used in Degree of Concern of Impacts Ratings for the Environmental Impact Assessment.

Magnitude of Impact[a]	**Direction of Impact**[b]	**Duration of Impact**[c]	**Frequency of Impact**[d]	**Scope (Geographical Extent) of Impact**[e]	**Degree of Reversibility of Impact**[f]
Low (< 1%)	Positive	Short-term (< 1 year)	Once	Local	Reversible
Moderate (1 - 10%)	Negative	Moderate (1 to 7 years)	Intermittent	Regional	Irreversible
High (> 10%)	Neutral	Long-term (> 7 years)	Continuous	Provincial	

(a) **Magnitude** refers to the percentage of a population or resource that may be affected. Where possible, the population or resource base has been defined in quantitative or ordinal terms (e.g., hectares of soil types, units of habitat). Impact magnitude has been classified as either less than (<) 1%, 1 to 10%, or greater than (>) 10% of the population, or resource base. If there is insufficient information available to quantify the percent impacted, the change has been identified only as an increase or decrease in the population or resource.

(b) **Direction** refers to whether an impact to a population or resource is considered to be a positive, negative or neutral effect.

(c) **Duration** refers to the time it takes a population or resource to recover from the impact. It is to be identified as short-term (< 1 year), moderate-term (1 to 7 years) and long-term (> 7 years).

(d) **Frequency** refers to the number of times an activity occurs over either the construction phase or the operations phase, and can be identified as once, intermittent, or continuous.

(e) **Scope** refers to the geographical area potentially affected by the impact and may be rated as local (Within Local Study Area), regional (Within Biophysical Cumulative Effects Study Area, or Air Resources Cumulative Effects Study Area), or provincial (extends outside Regional Study Areas). Where possible, quantitative estimates of the surface area affected by the impact has been provided.

(f) **Degree of Reversibility** refers to extent an adverse effect is reversible or irreversible over a 7 year period.

distribution of wind speed, wind direction and stability class. These models are used to predict annual average concentrations and depositions out to 100 km.

Regardless of how well a model imitates the behaviour of the atmosphere, there will be some uncertainty resulting from the random nature of atmospheric turbulence processes. The uncertainty in model predictions ranges from +/- 10% for the ideal dispersion case (Pasquill and Smith 1983) to +/- 200% for tall stack Gaussian model predictions (Smith 1981). Despite these uncertainties, predictions that are within a factor of two provide a better basis for decision-making than those made with no guidance whatsoever. By way of example, consider that pristine ambient background SO_2 concentrations are typically in the 0.0003 ppm range. A nearby industrial emission source can contribute 0.3 ppm to this background level. These two values range over three orders of magnitude, considerably greater than the anticipated uncertainty in a model prediction.

The selected dispersion models must be capable of representing local conditions. Required features for the proposed Solv-Ex facility include:

- A sequential time series approach that will allow multiple averaging periods and frequency analyses to be undertaken,

- Ability to recognize the effects of terrain elevation differences (e.g., the Athabasca River, Fort Hills, etc.),

- Recognition of diurnal and seasonal variations in the receptors' ability to uptake the emissions, and

- Overlap of plumes from nearby sources.

There are two levels of assessment in applying dispersion models. Dispersion modelling must meet both the "screening" and "refined assessment" modelling criteria (AEP 1994). A number of differing models with differing assumptions were used to help convey the variability of modelling predictions to the reader. ISCST2, RTDM3.2 and ISCON5 were used with both screening and sequential time series meteorology. The source parameters (e.g., stack heights, diameters, exit temperatures, exit velocities and pollutant release rates) used by the models are provided in Section 2.2.3. Further discussion of the models is presented in Appendix VIII.

5.2.2 SO_2 Predictions

5.2.2.1 Screening Meteorology Predictions

Normal SO_2 emissions are associated with the operation of the sulphur recovery plant, the acid plant and combustion of diesel oil. Abnormal SO_2 emissions are associated with hour-by-hour variations in the operation of the sulphur recovery plant or the acid plant. SO_2 emissions can also result from the upset flaring of the amine plant feed or the acid gas stream.

Normal Emissions of SO_2

Table 5.3 presents the maximum predicted hourly average SO_2 concentrations assuming the facility burns fuel oil. The predicted concentrations range from 126 to 419 $\mu g/m^3$. The predicted values associated with natural gas combustion are not provided in the figure. For the case where natural gas is burned, the range of SO_2 concentration predictions is from 103 to 319 $\mu g/m^3$. These maximum predicted values are less than the ambient air quality guideline of 450 $\mu g/m^3$ for SO_2 as a one-hour average.

Under normal operation with elevated terrain assumptions, the ISCST2 model maximum predicted values are associated with stable conditions (PG stability class F) and are predicted to occur 3.5 km downwind of the main stack. All other models and ISCST2 with flat terrain have maxima that are associated with unstable conditions (PG class A). For these unstable cases, the maxima are predicted to occur between 100 and 300 m downwind of the main stack.

Abnormal Emissions of SO_2

The abnormal scenario assumed simultaneous upsets of the sulphur recovery and the acid plants. As such, the abnormal case probably represents an unrealistic worst case emission.

The highest SO_2 concentrations are associated with abnormal emissions and elevated terrain assumptions. The predictions range from 166 to 542 $\mu g/m^3$; the highest prediction associated with ISCON5 occurs on-site. The highest off-site prediction by ISCON5 is 475 $\mu g/m^3$. The meteorological conditions associated with all of the maxima for abnormal conditions are identical to those associated with normal operations.

If the facility burns natural gas in place of diesel oil, the corresponding predictions of maximum SO_2 concentrations range from 145 to 446 $\mu g/m^3$, occurring between 300 and 620 m under unstable conditions (PG stability class A) and out to 3.5 km under stable conditions (PG stability class F).

For the worst case abnormal emission case evaluated, the air quality guideline for SO_2 of 450 $\mu g/m^3$ could be exceeded.

Emergency Flaring Events

The flare was modelled using ISCST2 under flat and elevated terrain for two cases: release of the amine plant feed to flare and release of the acid gas stream to flare. The maximum predicted SO_2 concentrations associated with the flaring of the amine feed stream did not exceed the maximum 1-hour ground-level concentration of 450 $\mu g/m^3$. For the case of the flaring of the acid gas stream, the flaring event would need to be limited to approximately 7 minutes to meet the one-hour guideline due to its lower heating value and subsequent lower plume rise.

Table 5.3 Summary of screening predictions of 1-hour average SO_2 concentrations: Diesel oil.

Terrain: Meteorology:	**FLAT Screening**		**ELEVATED Screening**	
Emission Scenario: **Model/Parameter**	**Normal**	**Abnormal**	**Normal**	**Abnormal**
ISCST2				
Maximum Model Prediction of SO_2 Concentration ($\mu g/m^3$)	229	302	581	763
Maximum **1-hr** Ground-level Concentration ($\mu g/m^3$)[(a)]	126	166	319	419
Distance from Main Stack (m)	707	707	3536	3536
Wind Direction (°)	100	100	225	225
Wind Speed (m/s)	1.5	1.5	1.0	1.0
Stability Class	A	A	F	F
ISCON5				
Maximum **1-hr** Ground-level Concentration ($\mu g/m^3$)	417	542	419	542
Distance from Main Stack (m)	300	300	300	300
Wind Direction (°)	0	0	0	0
Wind Speed (m/s)	3.0	3.0	3.0	3.0
Stability Class	A	A	A	A
RTDM				
Maximum **1-hr** Ground-level Concentration ($\mu g/m^3$)	n/a		238	331
Distance from Main Stack (m)	n/a		620	620
Wind Direction (°)	n/a		270	270
Wind Speed (m/s)	n/a		2.5	2.5
Stability Class	n/a		A	A

[(a)] Model prediction was multiplied by 0.55 as required by Alberta Environment (1994) to yield the 1-hour concentration.

5.2.2.2 Sequential Time Series Predictions

Normal Emissions of SO_2

Maximum hourly predictions from RTDM, ISCON5 and ISCST2 using the SandAlta meteorology under normal conditions are presented in Table 5.4. The maximum predicted one-hour average SO_2 concentrations associated with normal operation range from 313 to 406 $\mu g/m^3$, occurring between 300 and 1240 m under stable conditions (PG stability class A) and out to 3.5 km under unstable conditions (PG stability class F). With natural gas combustion at the facility, the maximum concentration range is from 251 to 319 $\mu g/m^3$. These maximum predicted values are less than the ambient air quality guidelines of 450 $\mu g/m^3$ for SO_2 as a one-hour average.

Maximum predicted one-hour average SO_2 concentration contours associated with the normal emissions are shown in Figure 5.1. The predicted concentrations around the village of Fort McKay are well below 50 $\mu g/m^3$. At the forestry tower, 6.5 km east of the Solv-Ex facility, the concentration of SO_2 is predicted to be approximately 75 $\mu g/m^3$ at the base of the tower.

Table 5.5 presents the maximum predicted SO_2 concentrations as daily, annual and growing season averages assuming normal operation. The maximum **daily** concentration of 130 $\mu g/m^3$ occurs 750 m downwind as predicted by the ISCON5 model. The Alberta guideline is 150 $\mu g/m^3$ for daily average SO_2 concentrations.

The ISCON5 model predicts the highest maximum **annual** concentration of 7.0 $\mu g/m^3$ to occur under normal operation. The Alberta guideline for SO_2 as an annual average is 30 $\mu g/m^3$.

The models can provide the frequency that the SO_2 concentrations will exceed a given concentration. In the case of **daily average** concentrations, those values above 100 $\mu g/m^3$ were calculated. The IUFRO guideline recommends that 100 $\mu g/m^3$ of SO_2 not be exceeded as a daily average more than 12 times in 6 months. This means that approximately 93% of the time, the daily average SO_2 concentration should be below 100 $\mu g/m^3$. As shown in Table 5.5, on average, the facility is expected to be in compliance with the 100 $\mu g/m^3$ guideline. Further discussion of the significance of this is included in Section 5.6.2.3.

During the **growing season** (from May to September, inclusive), the models were used to calculate the frequency of an hourly ground-level concentration of 132 $\mu g/m^3$ could be exceeded. The IUFRO guideline recommends 97.5% of the growing season hourly concentrations be below 132 $\mu g/m^3$. The Solv-Ex plant would produce SO_2 concentrations below this threshold for 96% of the growing season based on the ISCON5 model (Table 5.5). The other models predict between 97.1 and 99.6% compliance. The significance of this is discussed in Section 5.6.2.3.

All of the foregoing predictions are based on Phase II operation. Since Phase I will operate for approximately one year, it was modelled separately to assess the impact of the Claus sulphur plant incinerator emissions. The maximum predicted SO_2 concentration as a one-hour average is 175 $\mu g/m^3$ under normal operating conditions (1.4 t/d SO_2 emissions) based on the RTDM model. This value is less than the 450 $\mu g/m^3$ guideline.

Table 5.4 Summary of sequential time series predictions of 1-hour average SO_2 concentrations: Diesel oil.

Scenario: Meteorology:	NORMAL SandAlta	ABNORMAL SandAlta
SO_2 Source: **Model/Parameter**	**All Sources[(a)]**	**All Sources[(a)]**
ISCST2		
Maximum model prediction of SO_2 ($\mu g/m^3$)	578	760
Maximum **1-hr** Ground-level Concentration ($\mu g/m^3$)[(b)]	318	418
Distance from Main Stack (m)	3536	3536
Wind Direction (°)	225	225
Wind Speed (m/s)	110	1.0
Stability Class	F	F
ISCON5		
Maximum **1-hr** Ground-level Concentration ($\mu g/m^3$)	406	529[(c)]
Distance from Main Stack (m)	300	300
Wind Direction (°)	3	3
Wind Speed (m/s)	3.0	3.0
Stability Class	A	A
RTDM		
Maximum **1-hr** Ground-level Concentration ($\mu g/m^3$)	313	436
Distance from Main Stack (m)	1240	1240
Wind Direction (°)	264	264
Wind Speed (m/s)	1.1	1.1
Stability Class	A	A

(a) Sulphur plant incinerator, acid plant scrubber and all secondary sources.

(b) Model prediction was multiplied by 0.55 as required by Alberta Environment (1994) to yield the 1-hour concentration.

(c) Maximum prediction on-site is 529 $\mu g/m^3$, the first off-site prediction is 475 $\mu g/m^3$ to the south.

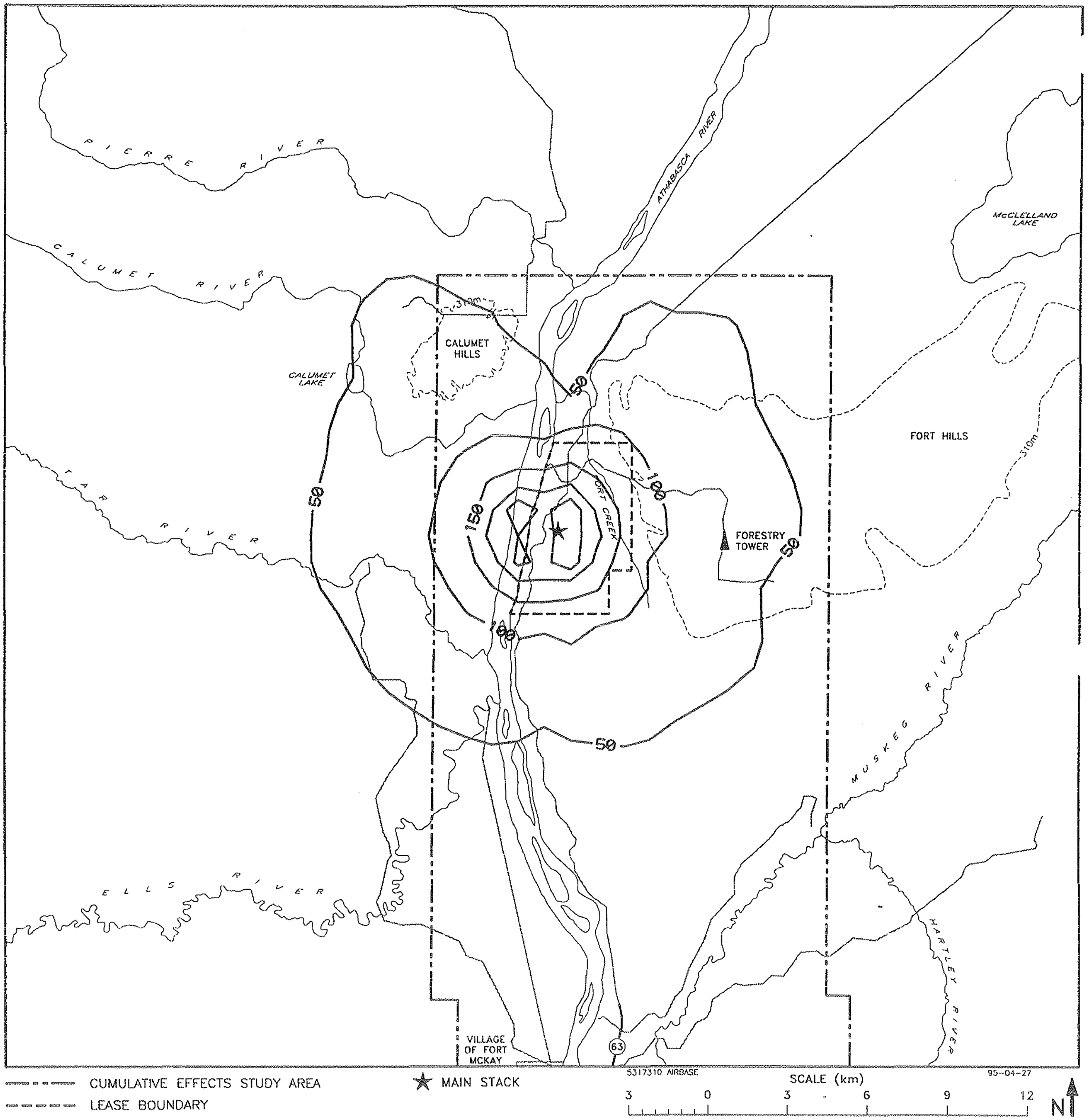


Figure 5.1 Maximum 1-hour average ground-level SO_2 concentration contours ($\mu g/m^3$) around the proposed facility predicted by the RTDM model under normal emissions.

Table 5.5 Summary of sequential time series predictions of 24-hour, annual and growing season average SO_2 concentrations: Diesel oil.

Scenario: Meteorology:	NORMAL SandAlta
Model/Parameter SO_2 **Source:**	**All Sources**[a]
ISCST2	
Maximum **24-hr** Ground-level Concentration ($\mu g/m^3$)	106
Distance from Main Stack (m)	5016
Daily Exceedences of 100 $\mu g/m^3$ (% days below)	99.9%
Maximum **Annual** Ground-level Concentration ($\mu g/m^3$)	3.4
Distance from Main Stack (m)	7071
Max. **Growing Season** 1-hr Ground-level Concentration ($\mu g/m^3$)	294
Distance from Main Stack (m)	5025
Growing Season Exceedences of 132 $\mu g/m^3$ (% compliance)	99.6%
ISCON5	
Maximum **24-hr** Ground-level Concentration ($\mu g/m^3$)	130
Distance from Main Stack (m)	750
Daily Exceedences of 100 $\mu g/m^3$ (% days below)	98.8%
Maximum **Annual** Ground-level Concentration ($\mu g/m^3$)	7.0
Distance from Main Stack (m)	750
Max. **Growing Season** 1-hr Ground-level Concentration ($\mu g/m^3$)	406
Distance from Main Stack (m)	300
Growing Season Hourly Exceedences of 132 $\mu g/m^3$ (% compliance)	96.0%
RTDM	
Maximum **24-hr** Ground-level Concentration ($\mu g/m^3$)	74
Distance from Main Stack (m)	730
Daily Exceedences of 100 $\mu g/m^3$ (% days below)	100%
Maximum **Annual** Ground-level Concentration ($\mu g/m^3$)	3.6
Distance from Main Stack (m)	7960
Max. **Growing Season** 1-hr Ground-level Concentration ($\mu g/m^3$)	312
Distance from Main Stack (m)	1240
Growing Season Hourly Exceedences of 132 $\mu g/m^3$ (% compliance)	97.1%

(a) Sulphur plant incinerator, acid plant scrubber and all secondary sources.

(b) Model prediction was multiplied by 0.55 as required by Alberta Environment (1994) to yield the 1-hour and the 24-hour concentrations. Exceedence limit values were divided by 0.55 to set the appropriate levels inside the model.

Abnormal Emissions of SO_2

Table 5.4 also presents the predictions associated with abnormal emissions from the proposed Solv-Ex facility. Predictions range from 418 to 529 $\mu g/m^3$. ISCON5 again predicts the highest value when the plumes from the main stack and the powerhouse overlap in a north-south orientation. Again, these abnormal predictions are based on simultaneous upsets in the sulphur recovery plant and the acid plant. The modelling indicates that under this worst case abnormal condition, the 450 $\mu g/m^3$ guideline may be exceeded.

Contours of SO_2 concentration resulting from the abnormal operation are presented on Figure 5.2. In the Fort McKay area, the maximum is predicted to be below 50 $\mu g/m^3$. At the forestry fire lookout tower, the concentration at the base of the tower is predicted to be 100 $\mu g/m^3$ under these abnormal emission conditions. The associated weather conditions are typically low wind speed, unstable atmospheric conditions.

In Phase I, the maximum predicted SO_2 concentration is 246 $\mu g/m^3$ under abnormal conditions with only the incinerator operating (1.98 t/d of SO_2 emissions). This value is well below the 450 $\mu g/m^3$ guideline.

5.2.3 *Deposition Loading*

Annual average sulphate deposition values were calculated for two baseline emission cases:

- A baseline case based on historical Syncrude and Suncor emissions.
- A baseline case based on Suncor's SO_2 reduction program.

The effect of the Solv-Ex operations was then superimposed on these baseline cases for the air resources local and regional study areas. The sulphate deposition is expressed as the total sulphate equivalent deposition (wet + dry) expressed (in units of kg SO_4^{-2}/ha/a) and as an Effective Acidity (EA) and Acidifying Potential (AP). The EA and AP is expressed in units of equivalent kmol H^+/ha/a. The Solv-Ex predictions are based on the diesel oil case and all predictions used the SandAlta meteorological data. All figures include a background EA of 0.07 kmol H^+/ha/a.

5.2.3.1 Baseline Deposition

Table 5.6 and Figures 5.3, 5.4 and 5.5 summarize the total predicted deposition for the two baseline cases. Based on historical emissions, the maximum predicted values are (Figure 5.3):

- Maximum Total Deposition (without background) 32.0 kg SO_4^{-2}/ha/a
- AP (with background) 0.69 kmol H^+/ha/a
- EA (with background) 0.74 kmol H^+/ha/a

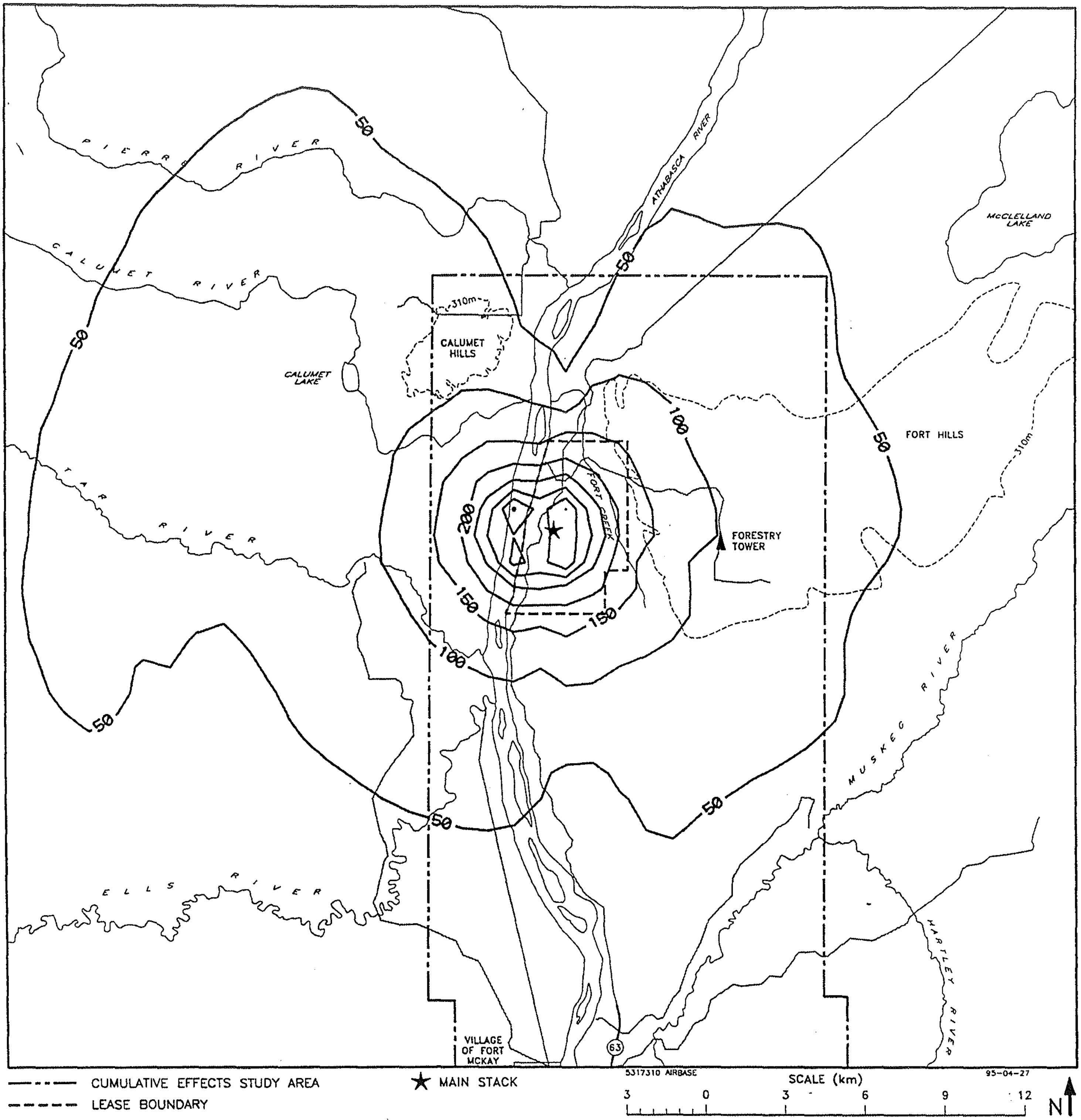


Figure 5.2 Maximum 1-hour ground-level SO_2 concentration contours ($\mu g/m^3$) around the proposed facility predicted by the RTDM model under abnormal emissions.

Table 5.6 Summary of background ADEPT2 predictions of annual sulphate-equivalent deposition.

		Historical	Future
	Emission Scenario	**Historical**	**Future**
	SO_2 Emission (t/sd):	**467**	**310**
Acidifying Potential (AP)			
Background AP	(kmol H^+/ha/a)	0.02	0.02
Predicted Wet + Dry	(kg SO_4^{-2}/ha/a)	32.0	9.9
	(kmol H^+/ha/a)	0.67	0.21
Total Acidifying Potential	**(kmol H^+/ha/a)**	0.69	0.23
Location	(km)	51 (SSE)	53 (SSE)
Effective Acidity (EA)			
Background Wetfall	(kmol H^+/ha/a)	0.07	0.07
Predicted Wet + Dry	(kg SO_4^{-2}/ha/a)	32.0	9.9
	(kmol H^+/ha/a)	0.67	0.21
Total Effective Acidity	**(kmol H^+/ha/a)**	0.74	0.28
Location	(km)	51 (SSE)	53 (SSE)

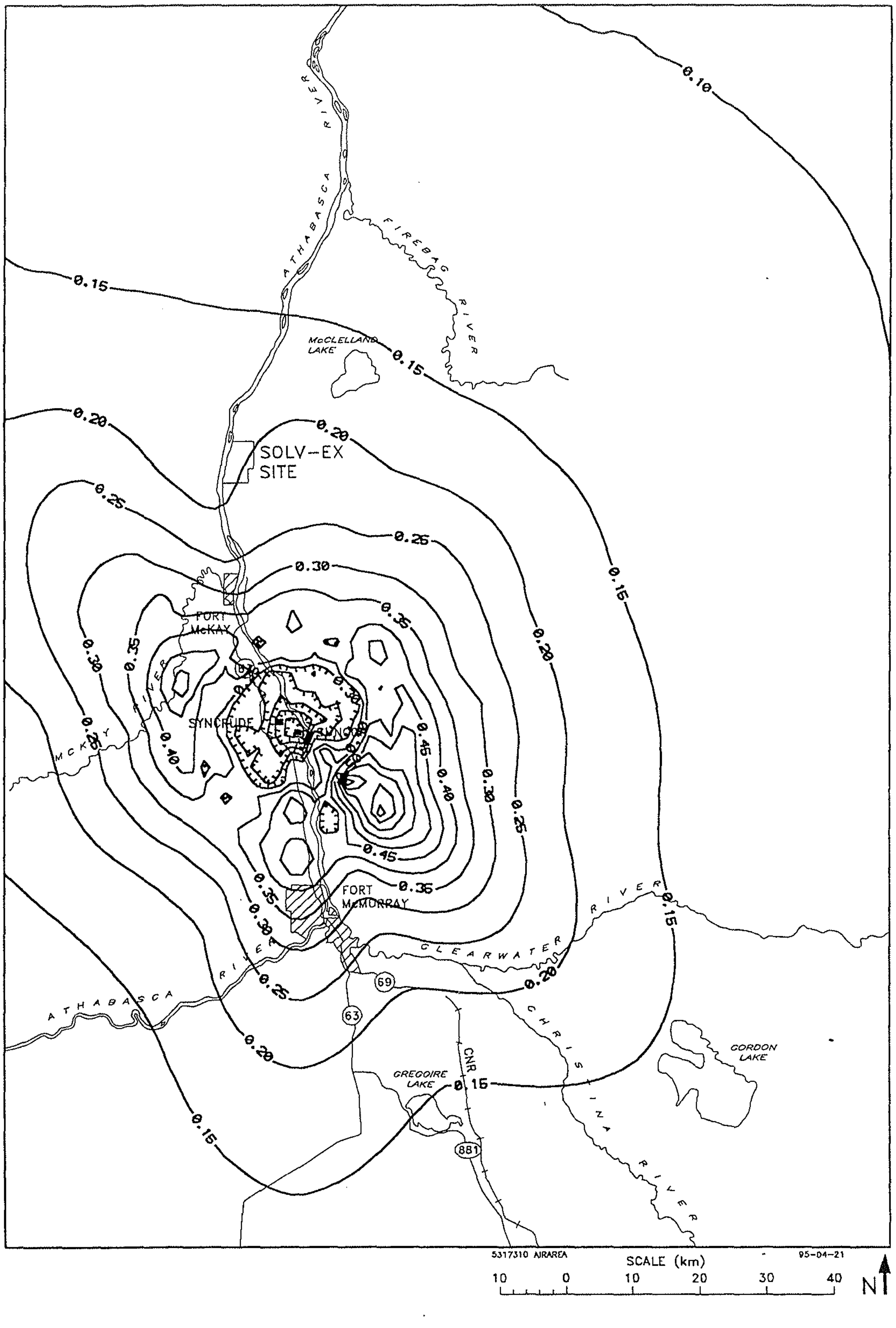


Figure 5.3 Total Effective Acidity associated with historical baseline emissions (Suncor and Syncrude 467 t/d SO_2 emissions). Contour interval = 0.05 kmol H^+/ha/a; Regional Study Area.

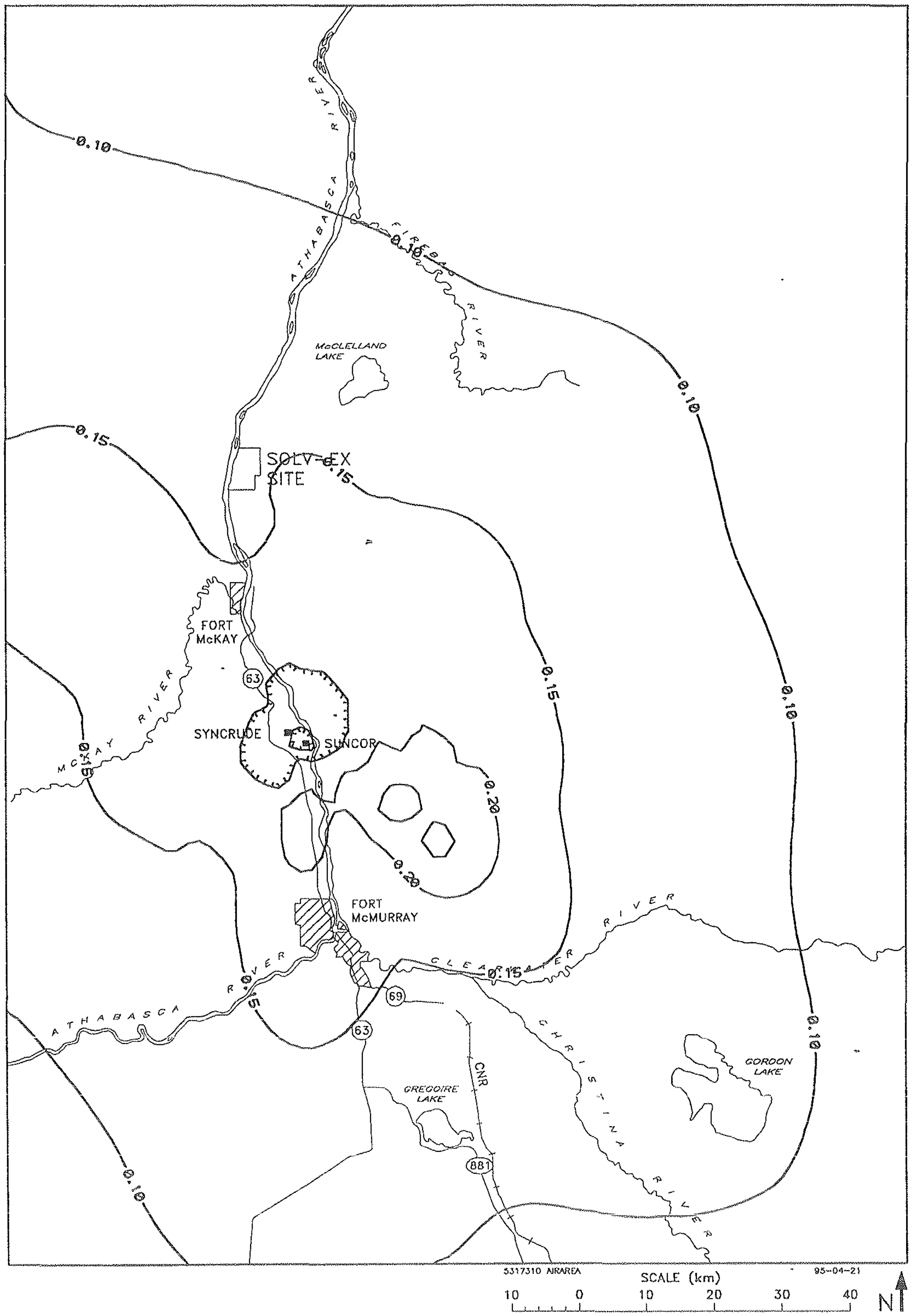


Figure 5.4 Total Effective Acidity associated with future baseline emissions (Suncor and Syncrude 310 t/d SO_2 emissions). Contour interval = 0.05 kmol H^+/ha/a; Regional Study Area.

Based on future emissions, the corresponding predictions are reduced to:

- Maximum Total Deposition (with background) 9.9 kg SO_4^{-2}/ha/a
- AP (with background) 0.23 kmol H^+/ha/a
- EA (with background) 0.28 kmol H^+/ha/a

The maximum values are predicted to occur 15 km to the southeast of the Suncor and Syncrude source area (Figure 5.4). This location is about 50 km to the south-southeast of the proposed Solv-Ex site. Figure 5.5 shows the future baseline predicted EA values in the Local Study Area. The effect of the SO_2 reduction project on the predicted Effective Acidity (EA) values is a significant reduction in magnitude and areal extent when compared with the corresponding historical emission values.

5.2.3.2 Solv-Ex Deposition

Table 5.7 and Figures 5.6 to 5.11 summarize the total predicted depositions for Solv-Ex alone and Solv-Ex with the two baseline cases. The results are presented for the local and regional study areas. More detail is provided for the local study area due to the increased resolution of the modelling. The specific results are as follows:

- Operation of Solv-Ex alone (Figures 5.6 and 5.7). With Solv-Ex operating in isolation and if **diesel oil** is burned, the maximum predicted deposition of 3.13 kg SO_4^{-2}/ha/a (without background) occurs 1830 m to the south of the main stack on site (Figure 5.6). Conservatively assuming that each mole of SO_4^{-2} is converted to two moles of H^+, this is equivalent to 0.07 kmol H^+/ha/a. If **natural gas** is burned at the facility, the maximum predicted deposition of 2.36 kg SO_4^{-2}/ha/a (without background) occurs 1830 m to the south. This is equivalent to 0.05 kmol H^+/ha/a.

- Historical operation of Suncor and Syncrude with Solv-Ex (Figures 5.8 and 5.9). The effect of the Solv-Ex operation is noticeable on the map in the immediate vicinity of the plant. The effect of the Solv-Ex operation where the maximum Effective Acidity is predicted to occur is negligible.

- Future operation of Suncor and Syncrude with Solv-Ex (Figures 5.10 and 5.11). Again, the effects of the Solv-Ex operation on the overall contour pattern is noticeable in the vicinity of the proposed plant and negligible elsewhere.

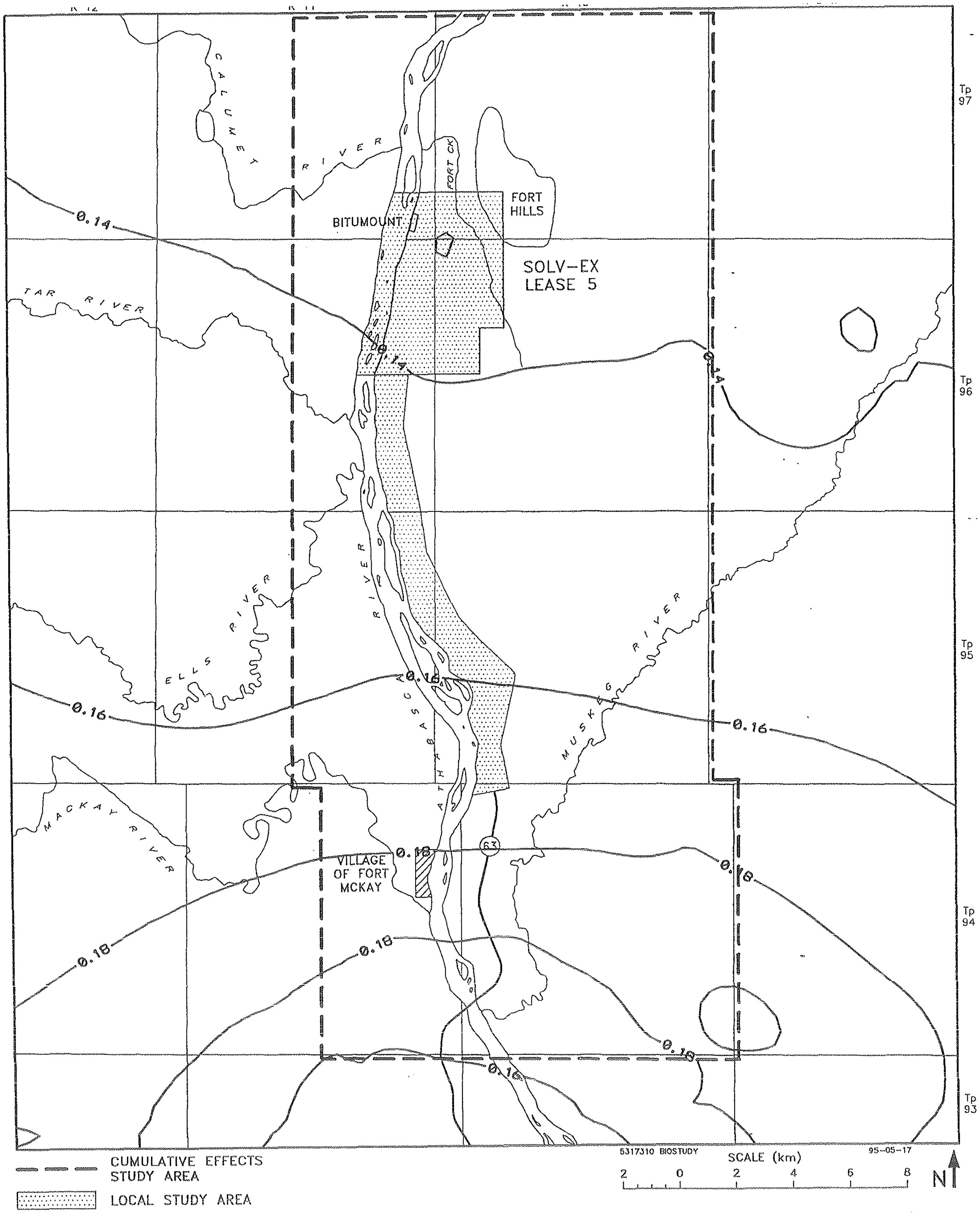


Figure 5.5 Total Effective Acidity associated with future baseline emissions (Suncor and Syncrude 310 k/d SO_2 emissions). Contour interval = 0.02 kmol H^+/ha/a; Local Study Area.

Table 5.7 Summary of ADEPT2 predictions of annual sulphate-equivalent deposition: Diesel oil.

Emission Scenario[a]		**Solv-Ex**	**Historical Combined**	**Future Combined**
SO_2 Emission (t/sd):		**7.4**	**474.4**	**317.4**
Acidifying Potential (AP)				
Background AP	(kmol H^+/ha/a)	0.02	0.02	0.02
Predicted Wet + Dry	(kg SO_4^{-2}/ha/a)	3.13	32.1	10.0
	(kmol H^+/ha/a)	0.07	0.67	0.21
Total Acidifying Potential	**(kmol H^+/ha/a)**	0.09	0.69	0.23
Location	(km)	1.83 (S)	51 (SSE)	53 (SSE)
Effective Acidity (EA)				
Background Wetfall	(kmol H^+/ha/a)	0.07	0.07	0.07
Predicted Wet + Dry	(kg SO_4^{-2}/ha/a)	3.13	32.1	10.0
	(kmol H^+/ha/a)	0.07	0.67	0.21
Total Effective Acidity	**(kmol H^+/ha/a)**	0.14	0.74	0.28
Location	(km)	1.83 (S)	51 (SSE)	53 (SSE)

[a] Solv-Ex case is contribution of proposed facility alone, combined cases include sources of Syncrude and Suncor.

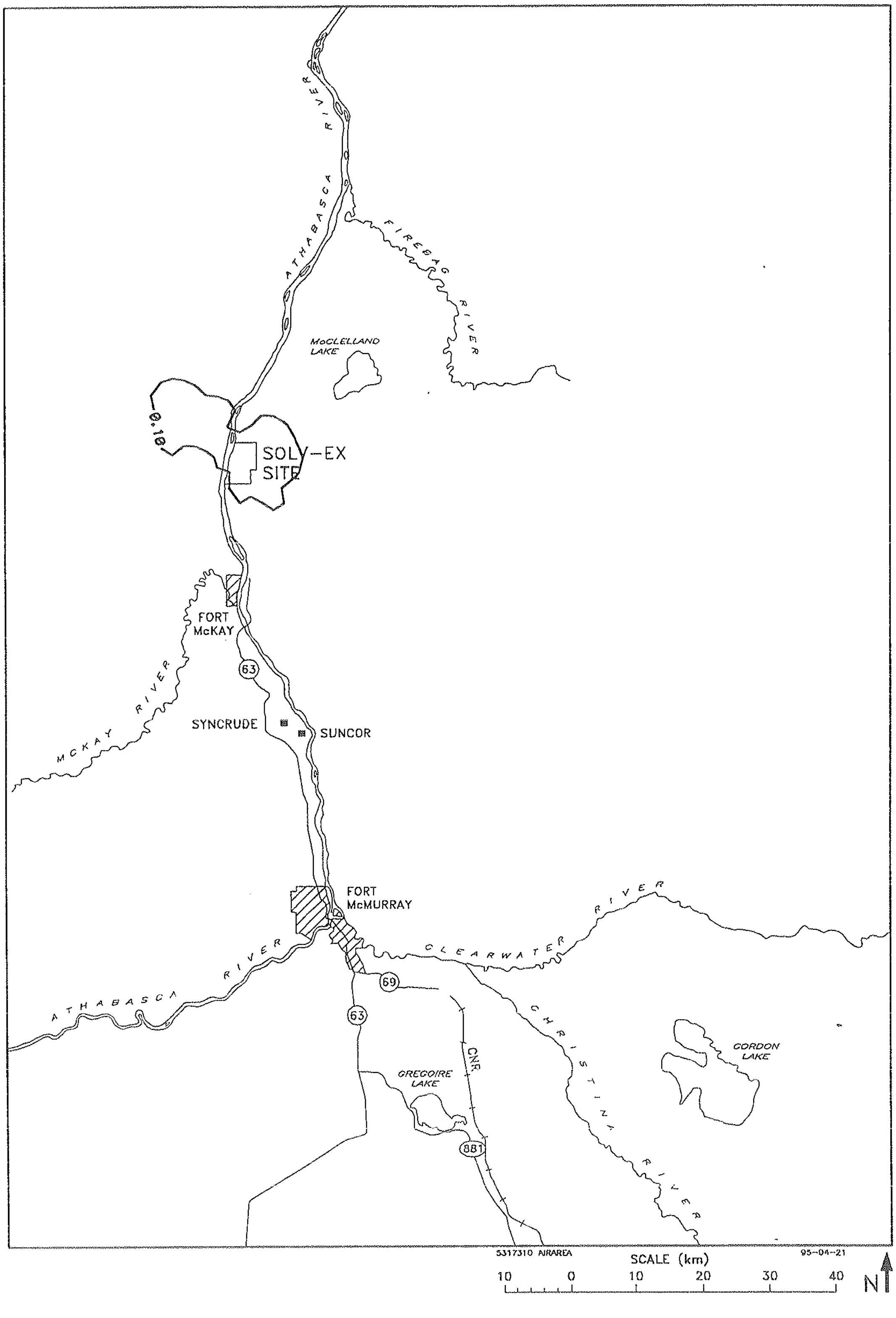


Figure 5.6 Total Effective Acidity associated with only the operation of the proposed facility (Total SO_2 emission = 7.4 t/d SO_2 emission). Contour interval = 0.05 kmol H^+/ha/a; Regional Study Area.

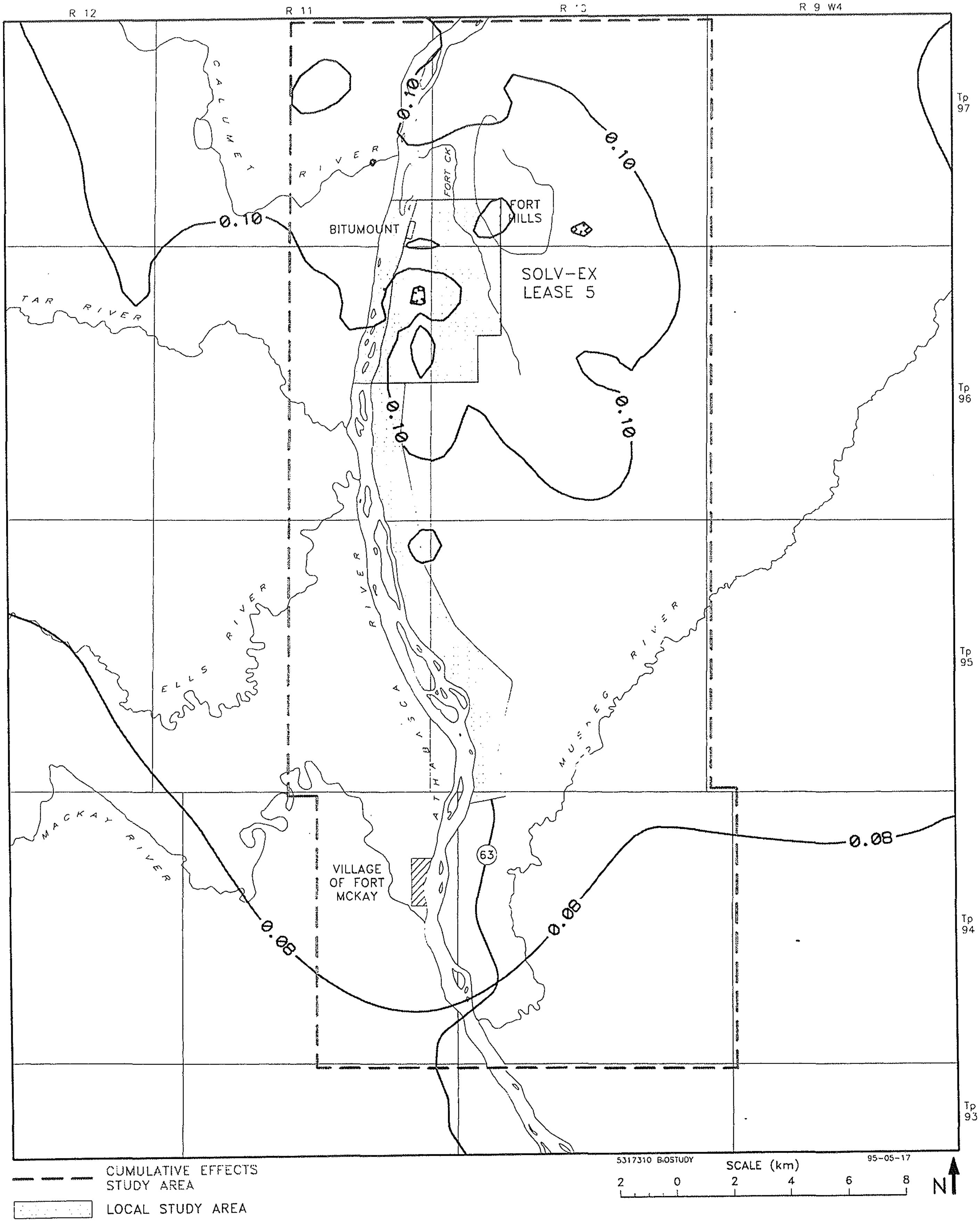


Figure 5.7 Total Effective Acidity associated with only the operation of the proposed facility (Total SO_2 emission = 7.4 t/d). Contour interval = 0.02 kmol H^+/ha/a; Local Study Area.

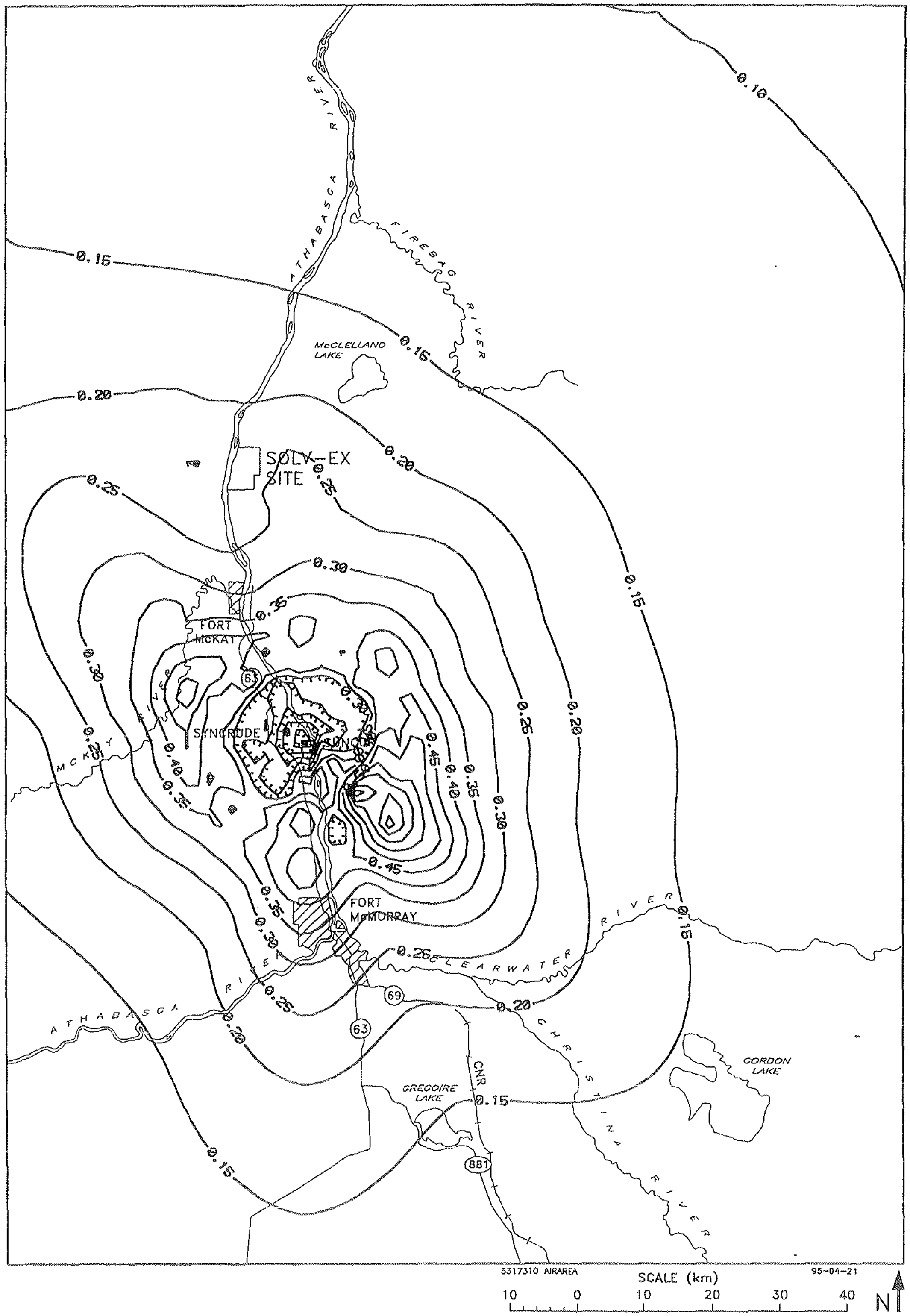


Figure 5.8 Total Effective Acidity associated with the combined Solv-Ex and historical baseline emission (Total SO_2 emission = 474.4 t/a). Contour interval = 0.05 kmol H^+/ha/a; Regional Study Area.

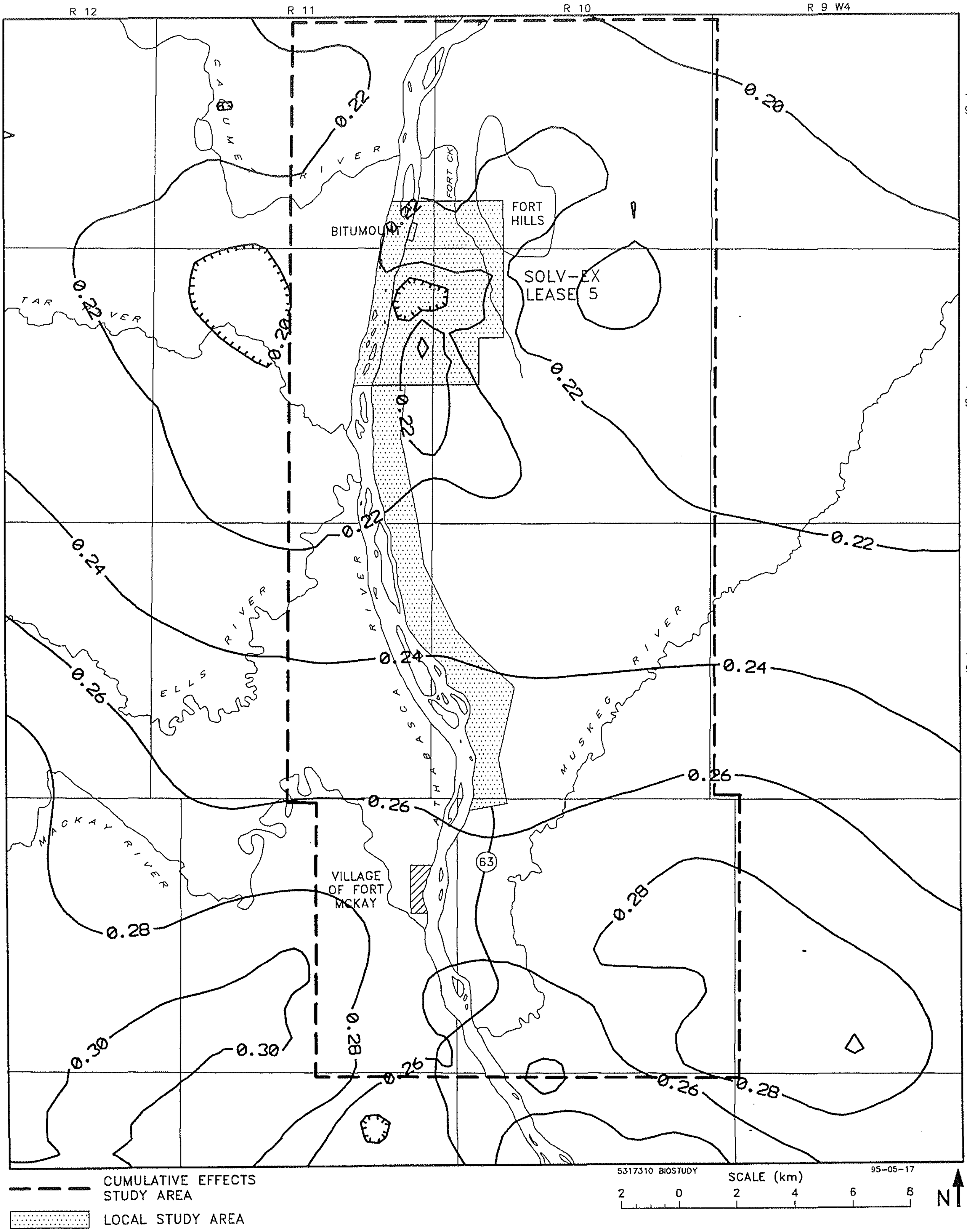


Figure 5.9 Total Effective Acidity associated with the combined Solv-Ex and historical baseline emission (Total SO_2 emission = 474.4 t/a). Contour interval = 0.02 kmol H^+/ha/a; Local Study Area.

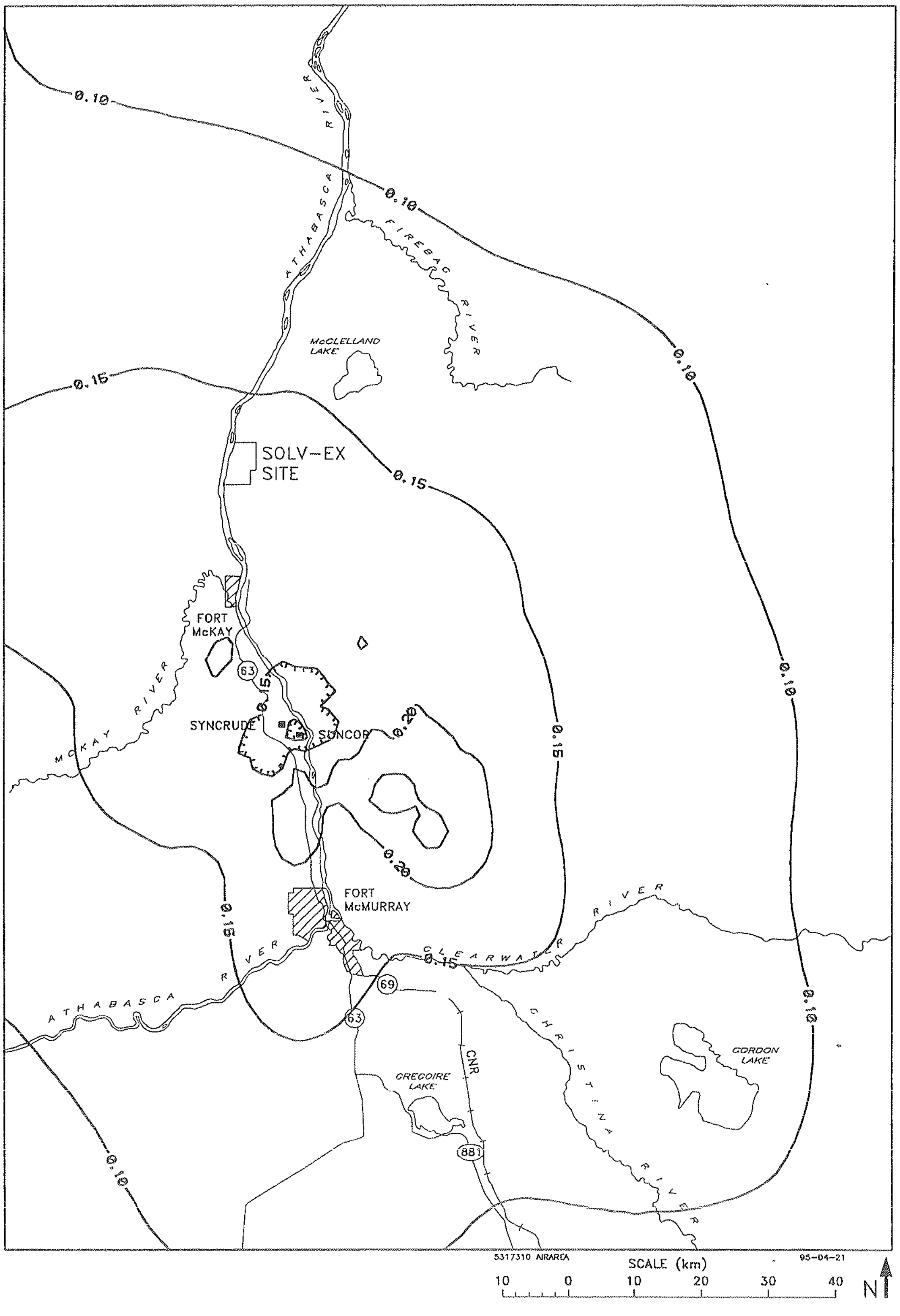


Figure 5.10 Total Effective Acidity associated with the combined Solv-Ex and future baseline emission (Total SO_2 emission = 317.4 t/a). Contour interval = 0.05 kmol H^+/ha/a; Regional Study Area.

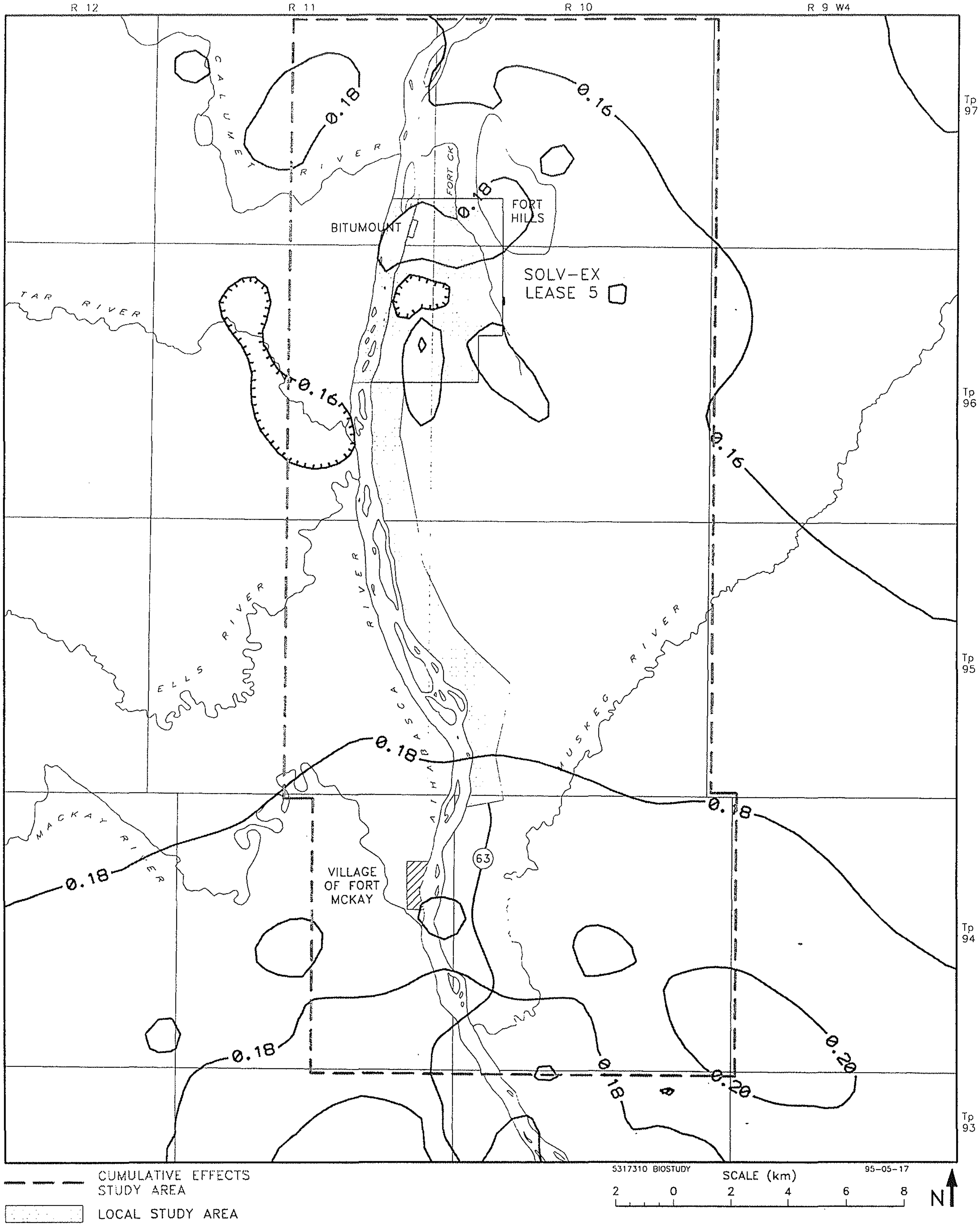


Figure 5.11 Total Effective Acidity associated with the combined Solv-Ex and future baseline emission (Total SO_2 emission = 317.4 t/a). Contour interval = 0.02 kmol H^+/ha/a; Local Study Area.

5.2.4 NO_x and NO_2 Predictions

The models predict concentrations of NO_x which is primarily comprised of NO. The corresponding NO_2 concentrations can be estimated from relationships provided by Alberta Environmental Protection (1994):

- The photostationary state method (daytime):
  $[NO_2] = k_3/k_1\ [O_3]\ [NO_x] / (1 + k_3/k_1\ [O_3])$;
  where $k_3/k_1 = 62.5$ in summer and 90.9 in winter; and $[O_3] = 0.026$ ppm background.

- The ozone limiting method:
  If $[O_3] > 0.9\ [NO_x]$, then $[NO_2] = [NO_x]$,
  or else
  $[NO_2] = [O_3] + 0.1\ [NO_x]$; where $[O_3] = 0.026$ ppm background.

Both methods were used to convert predictions of NO_x concentrations to NO_2. The NO_2 concentrations were then compared to the appropriate air quality objective for NO_2.

5.2.4.1 Screening Meteorology Predictions

The results from the ISCST2 screening run for NO_x and NO_2 with and without terrain effects, are given in Table 5.8. ISCST2 predicts a maximum of 95 $\mu g/m^3$ NO_2 (0.05 ppm) occurring on the plant site. The maximum off-site concentration is expected to be less. The guideline for NO_2 is 400 $\mu g/m^3$ (0.21 ppm) as a one-hour average.

5.2.4.2 Sequential Time Series Predictions

The results from the ISCST2 model using the sequential time series approach are summarized in Table 5.9. The maximum prediction is 72 $\mu g/m^3$ occurring approximately 40 m downwind from the centre of the plant site. Maximum **hourly** NO_2 concentrations are predicted to fall below the 400 $\mu g/m^3$ (0.21 ppm) guideline both on- and off-site. The meteorology associated with this maximum is an F stability class with a 1.7 m/s wind speed. Figure 5.12 shows the concentration contours of NO_x in a 2 km by 2 km square grid centred on the plant site.

The maximum predicted **daily** and **annual** NO_2 concentrations comply with the respective guidelines (200 and 60 $\mu g/m^3$). The values shown in the table do not include the NO_2 background level of 11 $\mu g/m^3$, however, given the relatively low value, the guidelines will still be met with this addition.

Since the total NO_x emission associated with the combustion of diesel oil is expected to be lower than that for natural gas, the predicted concentrations of NO_x and NO_2 are also expected to be lower than the values presented in Table 5.9 if diesel oil is burned at the facility in place of natural gas.

Table 5.8 Summary of screening predictions of 1-hour average NO_x and NO_2 concentrations: Natural gas.

Terrain: Meteorology:	FLAT Screening
Model/Parameter	
ISCST2	
Maximum Model Prediction of NO_x Concentration (μg/m^3)	246
Maximum **1-hr** Ground-level NO_x Concentration (μg/m^3)[(a)]	135
Maximum **1-hr** Ground-level NO_2 Concentration (μg/m^3)	95[(b)] / 63[(c)]
Distance from Main Stack (m)	35
Wind Direction (°)	283
Wind Speed (m/s)	2.0
Stability Class	F

Table 5.9 Summary of sequential time series predictions of maximum average NO_x and NO_2 concentrations: Natural gas.

Terrain: Meteorology:	FLAT SandAlta
Model/Parameter	
ISCST2	
Maximum Model Prediction of NO_x Concentration (μg/m^3)	211
Maximum **1-hr** Ground-level Concentration NO_x (μg/m^3)[(a)]	116
Maximum **1-hr** Ground-level Concentration NO_2 (μg/m^3)	72[(b)] / 61[(c)]
Distance from Main Stack (m)	41
Wind Direction (°)	265
Wind Speed (m/s)	1.65
Stability Class	F
Maximum **24-hr** Ground-level Concentration NO_2 (μg/m^3)	21[(b)] / 31[(c)]
Maximum **Annual** Ground-level Concentration NO_2 (μg/m^3)	0.5[(b)] / 0.8[(c)]

(a) Model prediction was multiplied by 0.55 as required by Alberta Environmental (1994) to yield the 1-hour concentration.

(b) As converted by the Photostationary State method (daytime):
$[NO_2] = k_3/k_1\ [O_3]\ [NO_x]\ /\ (1 + k_3/k_1\ [O_3])$; where
$k_3/k_1 = 62.5$ in summer and 90.9 in winter; and $[O_3] = 0.026$ ppm background.

(c) As converted by the Ozone Limiting method (assuming a background of 0.026 ppm O_3):
If $[O_3] > 0.9\ [NO_x]$, then $[NO_2] = [NO_x]$; or
$[NO_2] = [O_3] + 0.1\ [NO_x]$; where $[O_3]$ is background = 0.026 ppm.

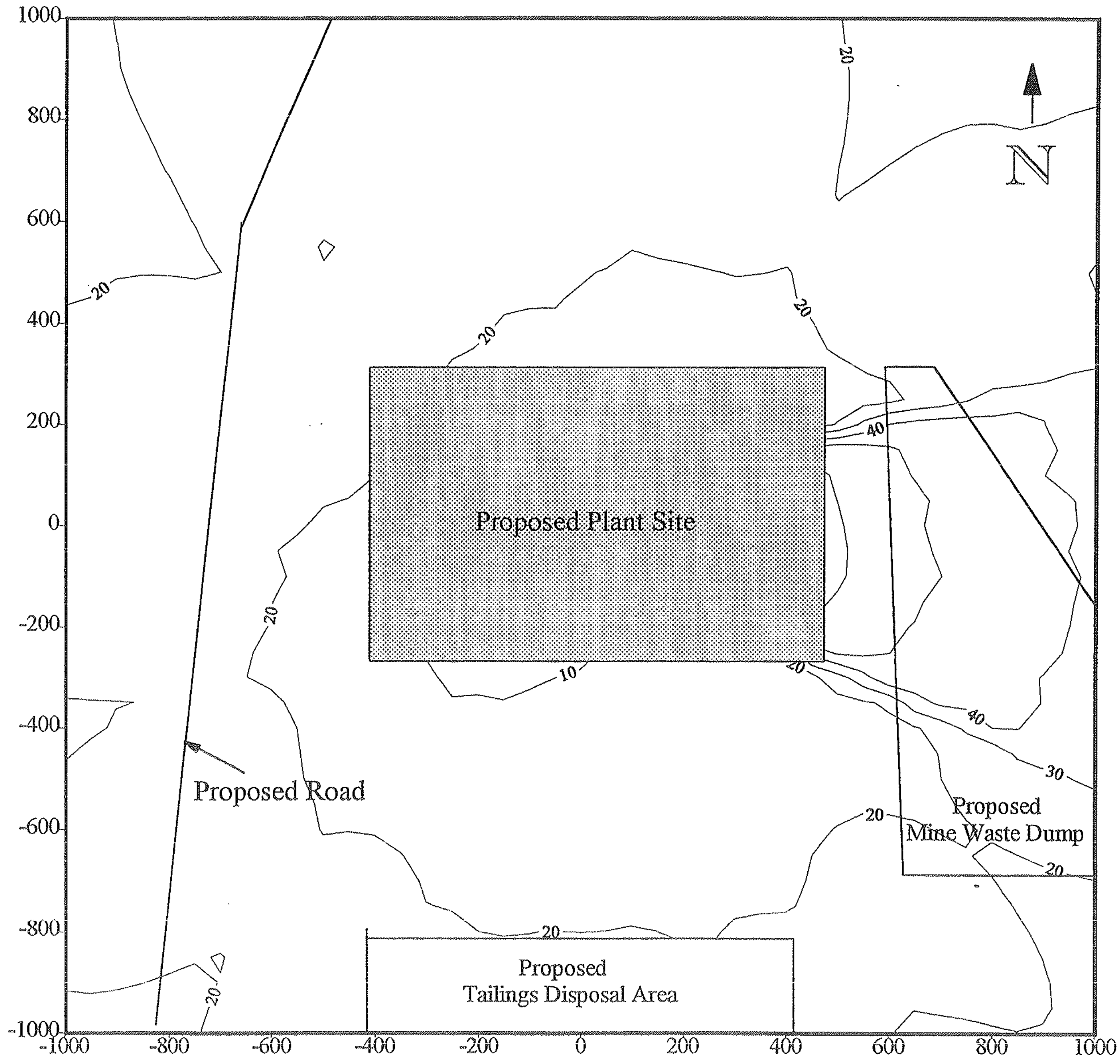


Figure 5.12 Maximum 1-hour ground-level NO_x concentration contours ($\mu g/m^3$) in a 2 km x 2 km area around the proposed plant site predicted by the ISCST2 model using SandAlta meteorology.

Table 5.10 Summary of screening predictions of 24-hour average particulate concentrations: Fuel oil.

Terrain: Meteorology:	FLAT Screening
Model/Parameter	
ISCST2	
Maximum Model Prediction of Particulate Concentration (µg/m³)	441
Maximum **1-hr** Average Ground-level Concentration (µg/m³)[a]	242
Maximum **24-hr** Average Ground-level Concentration (µg/m³)[b]	97
Distance from Main Stack (m)	240
Wind Direction (°)	103

[a] Model prediction was multiplied by 0.55 as required by Alberta Environment (1994) to yield the 1-hour concentration.

[b] Based on 1-hr maximum prediction multiplied by 0.4 (U.S. EPA 1992).

Table 5.11 Summary of sequential time series predictions of 24-hour and annual average particulate concentrations: Fuel oil.

Terrain: Meteorology:	FLAT SandAlta
Model/Parameter	
ISCST2	
Maximum Model Prediction of Particulate Concentration (µg/m³)	426
Maximum **1-hr** Average Ground-level Concentration (µg/m³)[a]	234
Maximum **24-hr** Ground-level Concentration (µg/m³)[a]	50
Distance from Main Stack (m)	503
Wind Direction (°)	120
Maximum **Annual** Ground-level Concentration (µg/m³)[a]	3
Distance from Main Stack (m)	458
Wind direction (°)	120

[a] Model prediction was multiplied by 0.55 as required by Alberta Environment (1994) to yield the 1-hour, 24-hour and annual concentrations.

5.2.5 *Particulates*

5.2.5.1 Screening Model Predictions

Table 5.10 summarizes the ground-level particulate concentrations from the ISCST2 model without terrain effects. The 24-hour maximum is expected to occur approximately 350 m from the centre of the site. The maximum daily prediction is within the Alberta guideline of 100 $\mu g/m^3$.

5.2.5.2 Sequential Time Series Predictions

Table 5.11 summarizes the daily and annual average maximum ground-level concentrations of particulates with SandAlta meteorology. Maxima are predicted to occur inside the plant process area. Both predictions are well within their respective guidelines (100 and 60 $\mu g/m^3$). The diesel oil case produces a particulate emission rate approximately 15% higher than that associated with the natural gas combustion and thus the predicted concentrations associated with the burning of natural gas are expected to be lower than indicated in Table 5.11.

5.2.6 *Noise*

Noise sources were discussed in Section 2.3.8 and 4.1.5. Noise will be within the ERCB Noise Control Directive i.e., 40 dBA Leq in a 1.5 km radius from the proposed plant. By keeping noise levels below the ERCB guideline for on-site and off-site noise, the noise from activities at the Solv-Ex facility should not impact residents in the vicinity. The noise sources have not been modelled at this stage of the design, since no detailed information is available on the proposed equipment.

5.2.7 *Other Issues*

5.2.7.1 NO_x, VOC's and Ozone

The Canadian Council of Ministers of the Environment (CCME) recommended that a management plan be developed for the control of oxides of nitrogen (NO_x) and volatile organic compound (VOC's) emissions. Increased ground-level ozone concentrations can be produced by the reaction of NO_x and VOC in the presence of sunlight.

Ground-level ozone concentrations in the Fort McMurray area was recently reviewed for Syncrude (Concord Environmental 1993). The conclusions based on the review of available data and dispersion modelling work indicated:

- Exceedences of the hourly guideline of 80 ppb is relatively infrequent ranging up to 18 h/a. Exceedences of the daily guideline of 25 ppb typically occur 130 to 160 d/a. This is comparable to those observed in the other rural areas of Alberta.

- The model indicated that ozone concentrations may be enhanced due to NO_x and VOC emissions from existing oil sands operations. The modelling also indicated that increases in NO_x emissions of about 8 t/d are expected to have a negligible effect on ozone concentrations in the area.

The review indicated the primary source of ozone appears to be the downward mixing of elevated ozone towards the ground with a secondary contribution due to local sources. As such, the NO_x emissions associated with the proposed Solv-Ex facility (~ 1 t/d) are not expected to affect regional ozone values.

5.2.7.2 Global Warming

A number of man's activities have been related to inadvertent climate modification on a global scale. These activities include overgrazing by domestic animals and deforestation which can lead to desertification; and the production of greenhouse gases which may lead to a global warming (SMIC 1971). In recent years, considerable political, scientific and international attention has focussed on the man-made production of greenhouse gases. These gases include:

- Carbon dioxide (CO_2) [57%]
- Chlorofluorocarbons (CFC's) [24%]
- Methane (CH_4) [13%]
- Nitrous oxide (N_2O) [6%]

The values in square brackets indicate the estimated contribution of each gas to total greenhouse warming in the 1980's (Etkin 1990). The production and consumption of fossil fuels result in CO_2 and CH_4 emissions to the atmosphere. Most of the discussion in the literature concerning greenhouse gas has focussed on CO_2 because of its larger contribution to the warming trend. For this reason CO_2 is frequently used to represent all greenhouse gases.

It is known that CO_2 concentration in the atmosphere has steadily increased over the period which coincides with increased fossil fuel consumption. For a doubling in the ambient CO_2 concentration, a temperature rise ranging from 3 to 5°C has been projected (Kellogg and Zhao 1988, Slingo 1989). Feedback mechanisms involving various cloud formation assumptions have postulated that the projected temperature rise be limited to less than 1°C (Mitchell *et al.* 1989). The issue of relating climate change to greenhouse gas emissions is difficult since manmade effects have to be superimposed on the natural climate variability and since all positive and negative feedback mechanisms have not been identified.

In spite of the complexities of assessing climate change, the concern over long-term climate change is an issue that is being addressed by the international community. For example, the Changing Atmospheric Conference held in Toronto (June 1988) issued a challenge to reduce global CO_2 emissions from the 1988 levels by 20% by the year 2005. This 20% reduction is based on slowing the change in order to provide countries with time to adjust to any climate changes.

A Federal/Provincial Task Force on Energy and Environment was formed to determine available energy options to reduce energy related CO_2 levels in Canada. In response to this task force, Alberta identified and estimated the CO_2 emissions from various sources in Alberta and compared

Alberta's CO_2 contribution to international and national sources. Alberta contributes approximately 22% of the national total. About 43% of the estimated CO_2 emissions in Alberta are from the use of natural gas and 10% are due to oil sands operations. In 1990, CO_2 emissions associated with surface-mined oil sands in Alberta accounted for 9.5 million t/a (SENTAR 1993). For 1996, total CO_2 emissions for Alberta have been estimated at 145 million t/a (Burn, 1989). The average annual contribution by the Solv-Ex facility to the total Alberta emissions for 1996 is estimated to be 0.01%.

In addition to the 10 000 bbl/a of crude oil to be produced at the Solv-Ex facility, 69 000 t/a of alumina are also to be produced. The total volume of CO_2 released by the proposed facility includes that associated with the mineral production. A facility dedicated to alumina production from bauxite ore, for example, would have to mine between 4 and 9% as much material (depending on the alumina content of the bauxite) as Solv-Ex to yield the same amount of alumina. While the separation processes would be similar to that proposed for Solv-Ex, the alumina production at Solv-Ex will not require any additional mining operations since the waste stream of the bitumen upgrading (tailings) is the feedstock for the alumina process. The amount of energy expended by an equivalent bauxite mine would depend upon the depth of the overburden, source of energy and transportation distances, among other factors. Solv-Ex, for example, uses approximately 3.2 MW to mine the equivalent of 69 000 t of alumina and releases 6700 t of CO_2 from the associated mining operation. Assuming for comparison purposes, the same mining conditions and equipment, Solv-Ex will therefore save from 130 to 300 kW of energy and 270 to 600 t of CO_2 per year by processing its tailings for alumina.

In summary, the greenhouse gas and global warming issues are an international challenge that some countries are willing to meet, while others show little interest in participating if it interferes with their economic growth. The increasingly popular environmental philosophy of "think globally, act locally" has to be tempered with the need to use resources in the most effective manner.

5.2.7.3 Fog and Visibility Restrictions

A number of activities can reduce ground-level visibilities in the vicinity of the existing Syncrude or Suncor oil sands operations:

- Burning of slash/debris during the clearing of a mine site.
- Water vapour emissions from stacks and/or tailings pond during the operation of the facility.

Burning operations introduce water vapour and particulate matter into the atmosphere which in the extreme can result in visibility restrictions similar to those observed from a forest fire. Water vapour emissions can produce local fogs during cold temperatures. When the temperature falls below -30°C, ice fog formation can occur leading to a further deterioration in visibility.

A study conducted by Syncrude (Murray and Kurtz 1976) indicated that the incidence of winter fogs could increase due to water vapour emissions from the plant facilities. Stack emissions are not a major cause of ice fog but may contribute to an existing fog on the ground (which depends on low-level sources). The Syncrude tailings pond is not expected to make a significant contribution to winter fog since it should be frozen over except where the hot tailings enter. Murray and Kurtz (1976) estimated water vapour emissions at Syncrude to be approximately:

- Open tailings pond 30 000 t/d
- Cooling tower 12 000 t/d
- Hot tailings 8000 t/d

In winter, about 20 000 t/d of water vapour might be emitted from the Syncrude facilities, neglecting the tailings pond.

In the case of Solv-Ex, the tailings are virtually dry. The process water vapour from heaters, etc., will be distributed among 12 stacks ranging in height from 20 to 60 m. The fog generally occurs within a shallow layer 10 to 30 m in depth. Since low temperature fog is associated with very stable conditions, limited interaction between the fog and the elevated plumes is expected. There are no significant ground-level sources at the proposed Solv-Ex facility.

The emission of water vapour associated with the operation of the proposed Solv-Ex facility is estimated as follows:

Source		Phase I	Phase II
Combustion	(t/sd)	400	800
Process	(t/sd)	10	1800
TOTAL	(t/sd)	410	2600

Solv-Ex water vapour emissions are two orders of magnitude lower than the Syncrude emissions estimated by Murray and Kurtz.

According to Environment Canada (1984), fog occurs on average one day per month during the November to April period when temperatures are cold enough to produce ice fog at the Fort McMurray Airport. This is about 0.4% of total hours in the period (Murray and Kurtz 1976). Because of the similar climate at Fort McMurray and the proposed Solv-Ex site, a similar frequency of natural fog occurrence should be expected.

There does not appear to be any follow-up studies since the Murray and Kurtz study to confirm their findings or establish a "low temperature fog baseline". It is likely that the most of the visibility restrictions due to oil sands plants occur within or immediately adjacent to the plants and are a result of cooling tower water vapour emissions. No cooling tower is planned for Solv-Ex.

It is unlikely that the visibility restriction will extend to nearby roadways, especially given the low expected water vapour emissions and thus there should be no impact on local traffic safety.

5.2.7.4 Local and Regional Climate Modification

The effects of the operation of the proposed facility with respect to the local and regional climate cannot be quantified. Studies focussing on detecting changes in meteorological parameters have been conducted in major cities and industrial areas which suggest that increased rainfall intensity and frequency (Khemani and Murty 1975; Changnon, Shealy and Scott 1991) and elevated temperature (Cayan and Douglas 1984; Kukla, Gavin *et al.* 1986) correlates with development of these areas. However, no studies at the small, isolated industrial scale such as Solv-Ex's proposal have been undertaken.

It is anticipated that neither wind speed nor wind direction will be altered from baseline conditions since the areal and vertical extent of the facility will be small. As a direct result of the additional heat energy released to the atmosphere and surroundings, there will be minor fluctuations in temperature on and around the plant process areas, but these phenomena should not influence mechanical structures, plant processes or gaseous releases to the atmosphere which would be expected to influence air flow patterns, temperature, precipitation frequency, or other meteorological phenomena locally (i.e., within a few kilometres) or regionally.

In addition, since there will be negligible climate modifications induced by the operation of the proposed facility, it is also concluded that adverse impacts on traffic safety will not occur as a result of changes in climate.

5.2.8 *Ambient Monitoring*

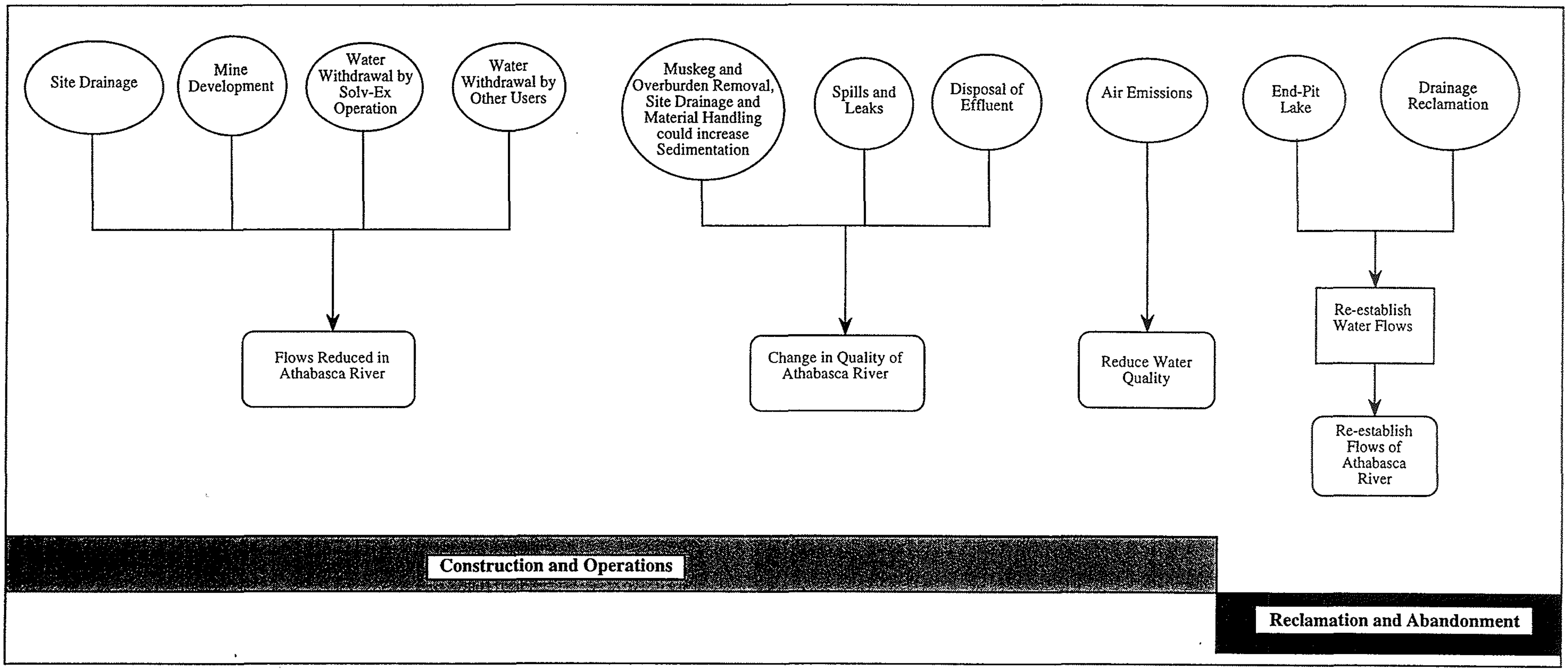
Solv-Ex proposes to conduct an ambient air quality monitoring program to better define background levels and changes associated with the operation. This program will consist of one ambient air quality trailer that will monitor SO_2, H_2S, THC, wind speed and wind direction on a continuous basis and maintenance of eight static sulphation stations. The selected locations will be based on the dispersion model predictions and discussions with AEP.

Solv-Ex proposes to become a member of the Regional Air Quality Committee (RAQC) when the company becomes an operator, potentially in 1997. In the interim, Solv-Ex will attend RAQC Meetings as a member of the public to provide input into the monitoring programs in the region.

5.3 Surface Water

This section addresses the impacts of the proposed Solv-Ex development on the water flow and quality of the Athabasca River, and on the quality of other waterbodies in the region (Figure 5.13). The proposed programs and measures to mitigate potential impacts are also discussed.

Figure 5.13 **Site drainage, mine development, water withdrawal by Solv-Ex and water withdrawal by other users of water will *reduce flows in the Athabasca River*, during the Life of the Operation, while the creation of the end-pit lake, and drainage restoration during reclamation and abandonment could *re-establish flows*. Activities that increase sedimentation, potential spills and leaks, and disposal of effluent (sanitary effluent, site drainage water and saline aquifer water) could change the *quality of water* in the Athabasca River. Air emissions could acidify waterbodies in the region.**



The following are project specific and regulatory givens used in the planning and layout of the facility which determine, to a large degree, the potential impacts on the surface water resources:

- Development setbacks from the top of the Athabasca River valley slope for the project facilities (Section 1.4).

- The mine's location is determined from mining considerations i.e., overburden thicknesses are minimal in the area, and environmental considerations i.e., mine is located on disturbed previously site. The plant site, waste material stockpile and tailings disposal area are located in deep overburden areas, and are necessarily located as close to the mine as possible.

- Siting of the plant site adjacent to a small drainage into the Athabasca River and east, or above, Highway 63 right-of-way.

- The construction and operation of all the facilities will require the construction of perimeter surface water drainage ditches to first of all drain the areas and secondly to isolate the "clean" external runoff from the development area. To the fullest extent possible, this water will be routed into the storage ponds at the plant site.

- Plant site runoff will be collected, stored, treated as necessary and recycled into the plant operation to the fullest extent possible. The storage ponds will be designed for the 1:10 year 24-hour event. In the plant area, the external runoff will, as necessary, be routed into the plant site for make-up purposes. Mine dewatering will be pumped to the storage pond at the plant site and utilized in the process.

- The Athabasca River is the only feasible surface water supply source for the plant site.

- Normal operational release of water into the Athabasca River will occur, only if water quality meets the appropriate Alberta Environmental Protection (AEP) Surface Water Quality Objectives. Potential releases to the river are as indicated on Figure 2.10 in the Water Management Section 2.2.1.

In assessing the potential impact on water quantity it is noted that:

- Water withdrawals will reduce flows in the Athabasca River. A water license application to Alberta Environmental Protection (AEP) will be required for withdrawals.

- An intake/pumphouse on the Athabasca River will be designed for minimum and maximum water levels and ice jams. The intake structure will be set back into the bank at a stable river location.

- The layout of the facility may require some diversion of the small drainage between the plant site and the tailings area.

5.3.1 *Impact on Athabasca River Flow*

In scoping the impact assessment, the following potential water quantity impacts on the Athabasca River (as identified on the hypotheses diagram) were eliminated from further discussion because of their small magnitudes:

- The impact of altered flow patterns in the small drainage in the plant site areas (as a result of plant runoff, site drainage and diversions around the facilities) on flows in the Athabasca River. The local drainage area, is less than 0.004% of the Athabasca River (drainage area in excess of 142 000 km^2), and

- The impact of mine dewatering on the quantity of flow in the Athabasca River. This flow, a relatively constant magnitude as it will be pumped, will be routed to the plant site raw water storage pond and utilization in the process and/or released, subject to AEP's water quality restrictions, to the Athabasca River. There is no reason to believe there will be an interchange of water between the Athabasca River and the mine. The 1995 drilling program will quantify the potential hydrogeologic connections between the river and the mine. If geological materials are porous, Solv-Ex will engineer mitigation to minimize water flow into the mine, and thus ensure pit integrity and worker safety.

The impact of Solv-Ex's water withdrawal on the monthly Athabasca River flows is as shown on Figure 5.14. Both the impact of the start-up demand of 5.0 Mm^3/annum, the average operations demand of 2.5 Mm^3/annum and the peak daily demand of 25% greater than the average daily demand are illustrated. The startup withdrawal will be 0.2% of the minimum recorded January Athabasca River flow if the startup of the plant coincided with a repeat of the lowest monthly flow in the 39 years of data analyzed. In the operations phase, the withdrawal would be less than 0.1% of the minimum recorded January flow.

The above assessment over-estimates the impact of the water withdrawal as:

- The local inflows from the Muskeg, and Steepbank and MacKay rivers were not included in the assessment. The withdrawals at Suncor and Syncrude offset this local inflow somewhat,

- Water recycling at the plant was not considered, and

- Local runoff in the plant site and disposal areas was not considered. (Even during the March 30, 1995 field evaluation, flow in the small creek in the plant site area was noticeable where it entered into the Athabasca River.)

Figure 5.14 also illustrates the relative Solv-Ex water demand compared to present demands by major water users from the Athabasca River such as Syncrude and Suncor. The impacts analysis was based on baseline flow data downstream of Fort McMurray which takes into account any water withdrawals upstream of this location. The licenced withdrawals of Syncrude and Suncor represent maximum allowable withdrawals and do not include substantial recycling volumes. The total cumulative effect of the three plants during the lowest historic flow month, and considering local run-off below Fort McMurray, is estimated to be less than 2%.

The usage of external runoff, plant water recycling and when available and desirable, use of mine dewatering, are the mitigative measures to be used to minimize the impact of water withdrawal. These measures are sound for technical and economic reasons from Solv-Ex's perspective and will further reduce the insignificant impact of water withdrawals on the Athabasca River. The water balance schematic illustrating recycling during the operations phase is as previously shown on Figure 2.10.

The residual impact of water withdrawal on the Athabasca River can be summarized as follows:

- Magnitude - Low (< 1% of the flows during the lowest recorded flow month),

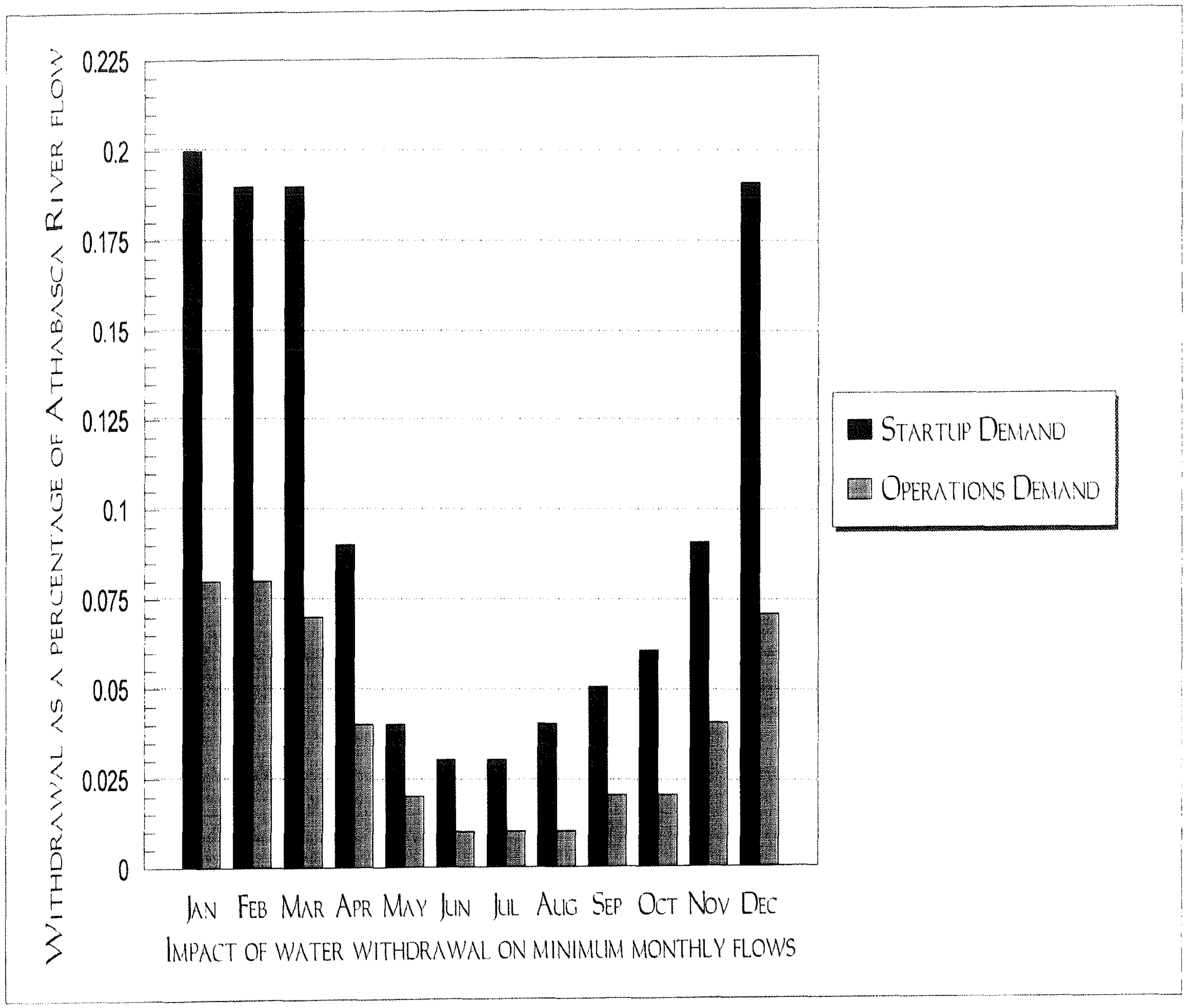
- Direction - Negative (reduces the Athabasca River flow),

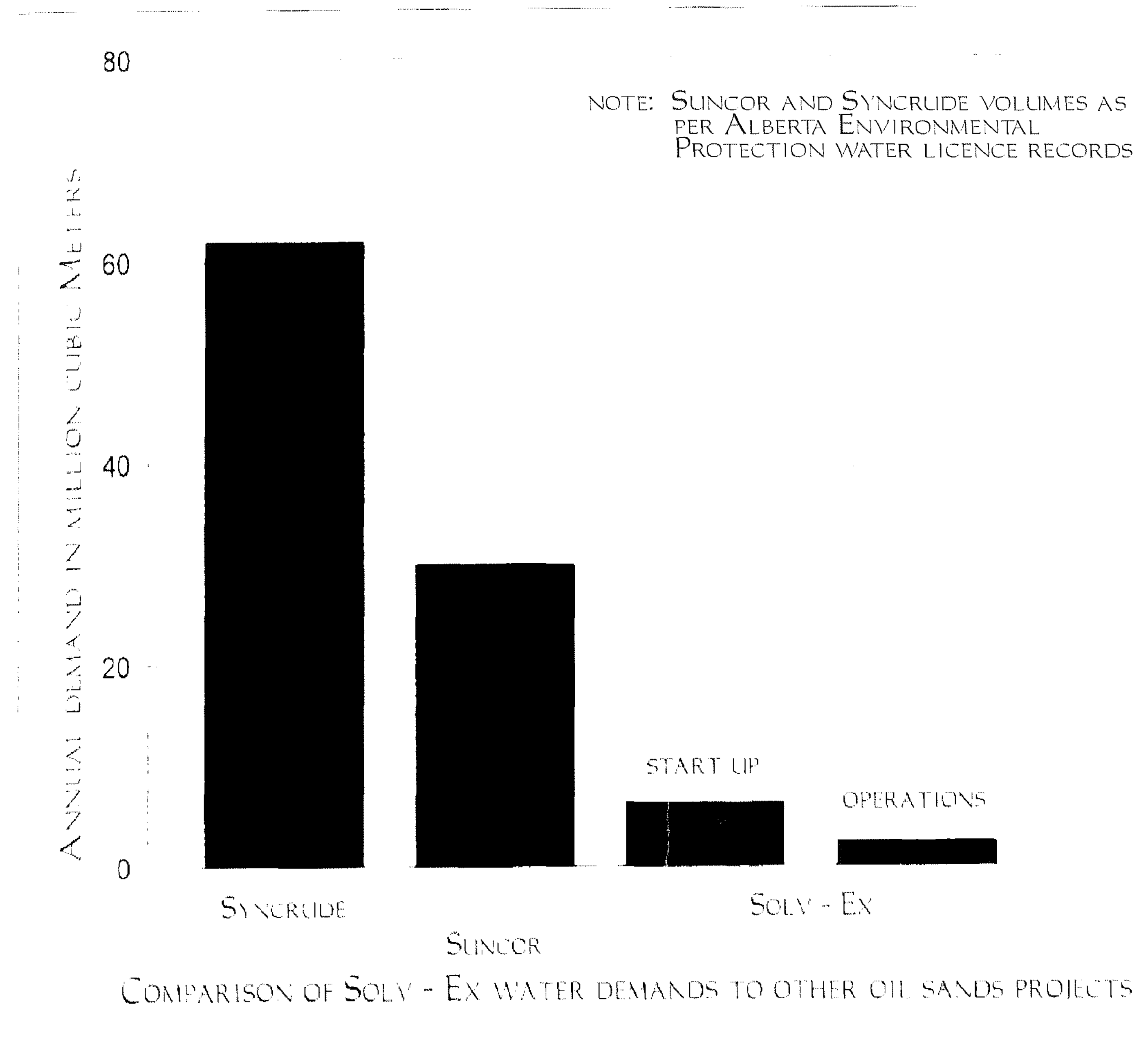
- Duration - For the Life of the Project (Long-term). Start-up is planned for 1996 with the operation of the experimental plant scheduled to last until 2002,

- Frequency - The actual withdrawal will depend on the available local runoff and possible dewatering from the mine site area. During short periods of perhaps several days to several weeks, local inflow could replace the need to pump from the Athabasca River. This effect is therefore labelled continuous,

- Scope - Theoretically, the geographic extent of the impact is regional to the Athabasca River delta. In realistic terms, however, even the maximum withdrawal percentage of 0.20% is not detectable on the flow or water levels of the Athabasca River. (Water Survey of Canada generally indicates their flow measurements to be accurate to ± 5%.), and

- Degree of Reversibility - Upon cessation of the Solv-Ex operation, water withdrawals cease and thus, this component of the project no longer has any impacts on the Athabasca River. As discussed previously, the project's impacts on local run-off, even after its completion, is insignificant with respect to the flow in the Athabasca River.





Note: Above impact percentages assume no recycling plant or use of external local runoff or minesite dewatering flow. The actual impacts will therefore be less than that shown.

Water withdrawal as a percentage of minimum Athabasca River flow

Figure 5.14

5.3.2 *Water Quality*

The project's design basis to minimize contamination of natural waterbodies is:

- Plant site and all other potentially contaminated runoff will be directed to a stormwater retention pond designed for the 1:10 year event. If not utilized for the plant's needs, the water will be treated as necessary in accordance with AEP's requirements prior to release to the external drainage into the Athabasca River. Recycling of the water for the plant's use and the size of the retention pond will minimize the need for discharge to the external environment.

- Clean external runoff, if not needed for the plant, may be discharged into the Athabasca River via the existing drainage. It will be diverted around the facilities to enter the drainage course through the Highway 63 culvert. A sediment (settling) pond will be excavated upstream of the culvert to control potential sedimentation particularly during initial site development.

Site development will involve road construction, muskeg and overburden drainage, removal of muskeg and organic material from the plant site and structure areas and placement of gravel for the plant site. In general, the potential impacts may be:

- Construction of highway culverts may require temporary stream diversions. Until vegetation is established in the road ditches and disturbed right-of-way, heavy rains and snowmelt will produce some sediment.

- Ditching for muskeg and overburden drainage will proceed from the downstream end in an upstream direction. The construction disturbance and initial flow in the ditches will produce some sediment, the amount depending on the soil characteristics and the flow at the time of construction. General experience with similar types of construction is that sedimentation occurs for a short period only.

- The construction of the gravel pads for the plant site buildings, and roads as well as the building of the stockpile and tailings area containment dykes will produce some sediment particularly during heavy rainfall events during and immediately following construction.

- Muskeg and overburden removal, and other material handling will cause some sediment particularly when the work is adjacent to the drainage ditches. These events will be staged throughout the Life of the Project.

Other potential effects on water quality will arise from:

- Release of sanitary effluent to the Athabasca River. Releases will be made in accordance with AEP criteria, i.e., Surface Water Quality Objectives.

- Release of saline water from the basal aquifer to the river. This will be pumped to storage ponds at the plant site, recycled and if released, mixed with clean water to meet AEP discharge criteria.

- Potential spills and leaks during plant upset conditions. A gated culvert in the Highway 63 crossing can be shutoff to contain potential spills.

The river intake/pumphouse, pipeline and access road will be located considering riverbank and channel stability, access gradients and slope stability considerations. Sound and thorough erosion control measures will be employed not only for environmental integrity reasons, but also to ensure a sound and dependable water supply, and access system.

Preliminary field evaluations and analysis of historic airphotos (Figure 5.15) indicate an intake/pumphouse setback into the bank is the most feasible option (Figure 5.16). It minimizes in-stream structures and construction activity which would be subject to flow and ice. Also it minimizes the need for in-stream work in the Athabasca River.

A pipeline will run from the intake/pumphouse to the plant site. The pipeline's and road's routing - a combined corridor will probably be used - will be determined following detailed field evaluations to support the water license application and the design of the facility.

With sound design and routing of plant site and facility runoff through sediment pond(s), the impact of Solv-Ex on sediment concentrations in the Athabasca River will be insignificant and will not be detectable. During high runoff periods, the potential local sediment production will be significantly less than the present summer sediment concentrations in the Athabasca River (Figure 4.21). During low flow and sediment periods in the winter, sediment production from the facility will be minimal to nil as there is no melting or runoff during this period.

Sound design basis, as discussed above, will be the prime means by which the impact on the Athabasca River will be minimized. In addition to this, a sediment pond and gated drop inlet pipe will be constructed upstream of and through the Highway 63 crossing of the drainage at the plant site. (Similar to that used at Alsand's outlet channel into the Muskeg River.) Directing the plant site drainage and external runoff into this drainage course is essential as uncontrolled discharge down the slope of the Athabasca River would result in serious erosion and possible slope instabilities.

Based on the above, it is concluded that although sediment will be generated by the proposed facility, the residual impact on the water quality of the Athabasca River will be:

- Magnitude - Low (<1%),

- Direction - Negative (marginal increase during the construction phase),

- Duration - Long-term although noticeable sediment will only occur during the first several years,

- Frequency - Infrequent during heavy rainfall events,
- Scope - Local in terms of extent of impact, and
- Degree of Reversibility - Irreversible as the permanent changed landscape conditions may produce slightly more sediment than the natural state.

As discussed previously, all releases into the Athabasca River will be made in accordance with AEP's guidelines. In the event of an upset condition or accident, the gate in the Highway 63 culvert will be closed to prevent offsite runoff.

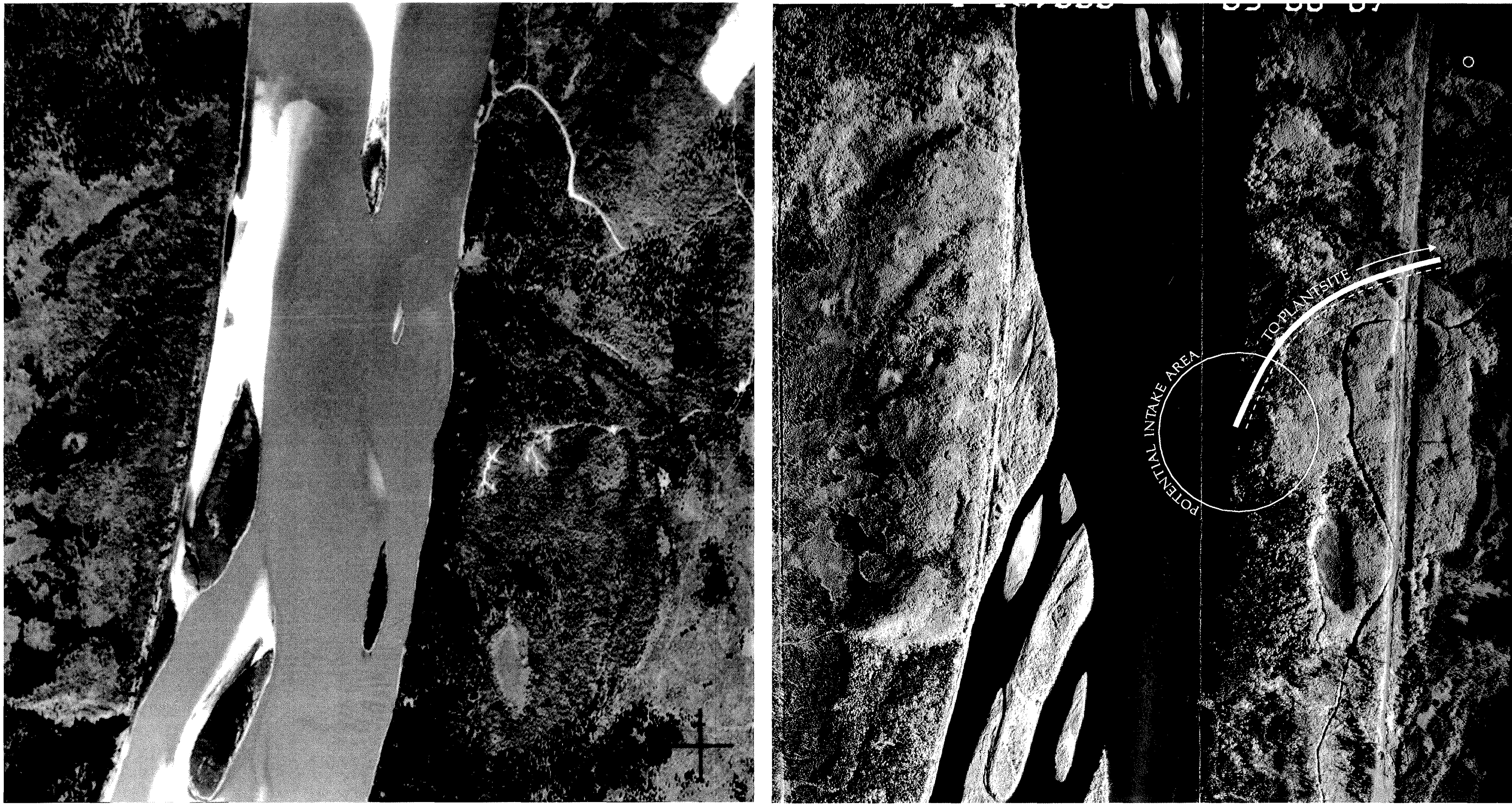
5.3.2.1 Acidification of Waterbodies

Changes in the concentrations of emissions associated with the Solv-Ex project that could effect water quality are summarized below:

- The predicted Acidifying Potential deposition for SO_2 emissions from the Solv-Ex project (plus background) reaches a peak of 0.09 kmol H^+/ha/a (Table 5.7), which is well below the critical target loading to protective sensitive waterbodies e.g., 0.12 to 0.31 kmol H^+/ha/a.

- The Predicted Effective Acidity (EA) deposition for the SO_2 emissions from the Solv-Ex operation (plus background) reaches a maximum of 0.14 kmol H^+/ha/a, about 1.8 km south of the proposed plant site (Table 5.7). These loadings fall in the bottom third of the range of target loadings, i.e., 0.1 to 0.3 kmol H^+/ha/a, adopted by Alberta Environment (1990) to protect highly sensitive waterbodies from acidification. The area under the 0.1 kmol H^+/ha/a is illustrated in Figures 5.6 and 5.7. The total area of waterbodies (Calumet, Lillian and 3 unnamed waterbodies) within the 0.01 kmol H^+/ha/a contour is 1.1 km^2, and the length of rivers and creeks is 2.3 km (including portions of the Athabasca and Calumet rivers and Fort Creek). Based on the existing information, waterbodies where the EA values are above the critical target loadings have low susceptibilities to acidification (determined by pH and alkalinity).

- The Predicted AP and EA deposition from the combined Solv-Ex, Suncor (reduction scenario) and Syncrude operations (cumulative effects) reach peaks of 0.23 and 0.28 kmol H^+/ha/a, respectively, located 53 km to the south-southeast of the Solv-Ex plant (Table 5.7). The Solv-Ex operation contributes no acidifying potential at this peak location (compare Figures 5.4 and 5.10). The Solv-Ex plant emissions do increase the acidifying potential in the immediate vicinity of the proposed plant site, where maximum combined EA values of 0.20 kmol H^+/ha/a are reached (Figure 5.11). As noted earlier, none of the lakes in the area influenced by Solv-Ex emissions are sensitive to acidification.



0 500
SCALE IN METERS

1950

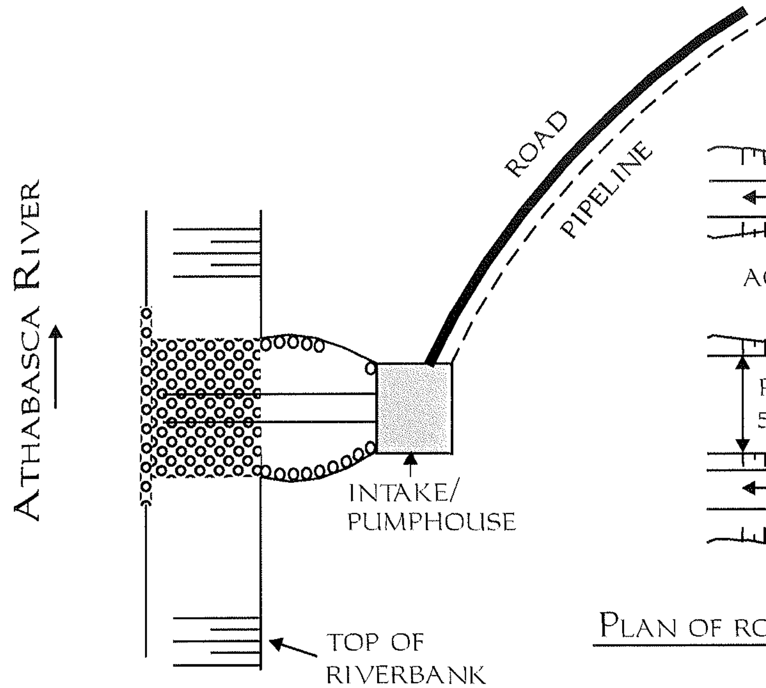
NOTE: PHOTOS USED TO ILLUSTRATE
RIVER CHANGES OVER TIME

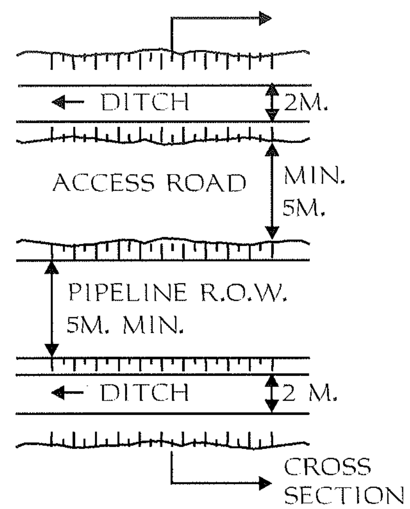
N

1989
APPROX. SCALE 1:10,000

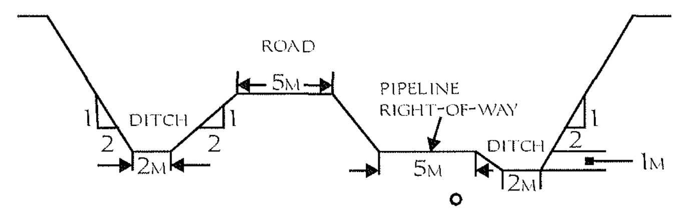
ROAD
WATER PIPELINE

COMPARITIVE AIRPHOTOS ATHABASCA RIVER WATER INTAKE
FIGURE 5.15

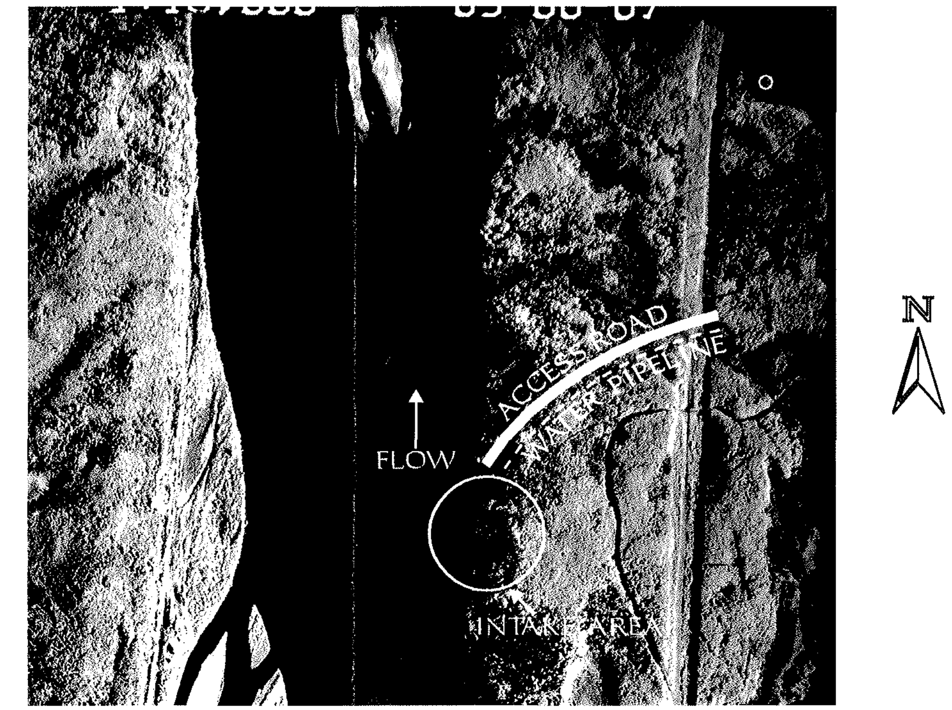




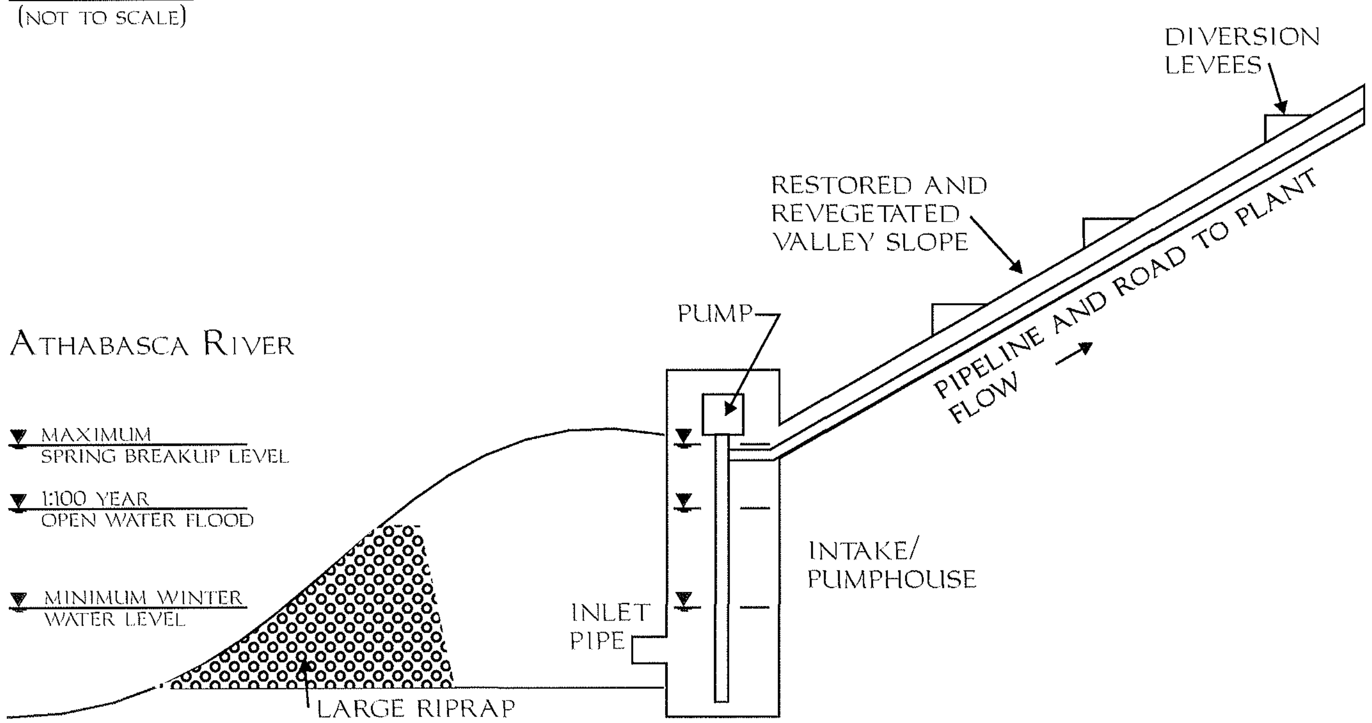
PLAN OF ROAD / PIPELINE CORRIDOR



CROSS SECTION



PLAN
(NOT TO SCALE)



PROFILE
(NOT TO SCALE)

NOTES:

1. INTAKE LOCATION TO BE DETERMINED CONSIDERING:
   - RIVERBANK STABILITY,
   - VALLEY SLOPE STABILITY, SEEPAGE AREAS AND FEASIBLE PIPELINE ROUTES,
   - FEASIBLE PUMPHOUSE ACCESS ROAD ROUTING.
2. DESIGN PREMISE FOR INTAKE STRUCTURE IS:
   - SET INTO RIVERBANK, OUT OF FLOW AND ICE FLOES,
   - LARGE RIPRAP ARMOURS BANK, ALLOWS FLOW TO PERCOLATE THROUGH AND ENSURES RIVER BEDLOAD MOVEMENT IS PASSED BY.
3. ROAD AND PIPELINE RIGHT - OF - WAY TO BE WELL DESIGNED AND INCORPORATING THE FOLLOWING FEATURES:
   - REVEGETATED CUT SLOPES
   - ARMOURING OR DROPS (ROCKS OR STRAW BALES) IN THE DITCHES

ATHABASCA RIVER WATER INTAKE
SCHEMATIC LAYOUT AND DESIGN
FIGURE 5.16

In summary, based on existing information, waterbodies in the region should not be at risk of acidification from SO_2 concentrations from the Solv-Ex plant, even when combined with deposition values from the Syncrude and Suncor plants.

5.3.3 *Summary of Residual Impacts*

The residual impacts of the Solv-Ex Experimental Co-production project on the Athabasca River flows during the Life of the Project (since withdrawals will cease at abandonment, there will be no post-operation impacts), and on the quality of the Athabasca River and other waterbodies in the region during the Life of the Project and Post-Operation are summarized below.

The increase in acidifying emissions from the Solv-Ex project is not predicted to change the quality of surface waters in the region. Information on the sensitivity of waterbodies contained within Effective Acidity and Acidifying Potential contours that exceed the critical target loadings (representing the SO_2 emissions from the Solv-Ex plant and from the Solv-Ex and future Syncrude and Suncor plants) indicates these waterbodies should not be at risk of acidification.

All effluent (sanitary, saline depressurization water, and site drainage water) will meet AEP's Surface Water Quality Objectives before being released to the Athabasca River, and thus should not affect the quality of this watercourse.

There is not expected to be any significant increase in suspended sediment loadings in the Athabasca River due to muskeg and overburden removal and site drainage, as all local run-off will be routed through sediment ponds prior to discharge to the external environment. The releases from the sediment ponds, in accordance with AEP criteria, will generally be at a lower sediment concentration than that of the Athabasca River.

There is not expected to be an increase in local suspended sediment in the Athabasca River over the short-term during the post-operation phase, as drainage patterns are re-established but the end-pit lake will act as a large-scale sediment trap and minimize this effect over the long-term.

The potential for exchange of water between the mine and the Athabasca River has not yet been determined. Geotechnical investigations through drilling in 1995 will be used to evaluate this potential impact, and potential effects on the flow or quality of the river. If necessary, Solv-Ex will engineer mitigation to minimize water flow into the mine, and thus ensure pit integrity and worker safety (Undetermined Impact).

Life of Operation:

- Withdrawal of water from the Athabasca River, for plant make-up will reach a maximum of 5.0 Mm^3 per year and will require a Licence under the Water Resources Act. There could be up to a maximum 0.2% decrease in Athabasca River flows during the lowest recorded flow month, if this occurred coincident with startup, due to these withdrawals. This impact is considered Low in magnitude, Negative, Moderate-term in duration, Regional in geographic extent, Continuous and Irreversible during the operations phase.

Post-Operation:

- Surface drainage will be re-established in the Development Area through the re-development of portions of original streams, and the development of a new end-pit lake. This impact is considered Low in magnitude, Positive, Long-term in duration and Regional in geographic extent.

5.3.4 *Surface Water Monitoring*

The following monitoring program will be undertaken during the start-up and operation of the proposed facility:

- Water withdrawals from the Athabasca will be monitored and recorded at the pumphouse at the Athabasca River,

- The total flow returned to the Athabasca River via the small drainage at the plant site will be monitored at the gated culvert at Highway 63,

- If the dewatering from the mine is discharged directly into the Athabasca River, the rate will be monitored at the pumps in the mine,

- Releases from on-site ponds will be monitored in accordance with AEP regulations, and

- During any plant upset conditions which result in releases to the external environment, water quality will be continuously monitored as deemed necessary until normal operations are resumed.

5.4 Groundwater

5.4.1 *Sources of Impacts to Groundwater*

Groundwater levels could be affected by mine site drainage, overburden removal, depressurization of the basal aquifer, and restoration of drainages (Figure 5.17). Groundwater quality could be affected by hydrocarbon tank area, storage areas for sulphur and pitch, landfill, tailings disposal area and potential for spills and leaks (Figure 5.18).

Figure 5.17 **Mine site drainage, overburden removal and basal aquifer depressurization (during the construction and operations phase) and drainage restoration during the reclamation and abandonment phase will *affect groundwater levels* in the vicinity of the mine.**

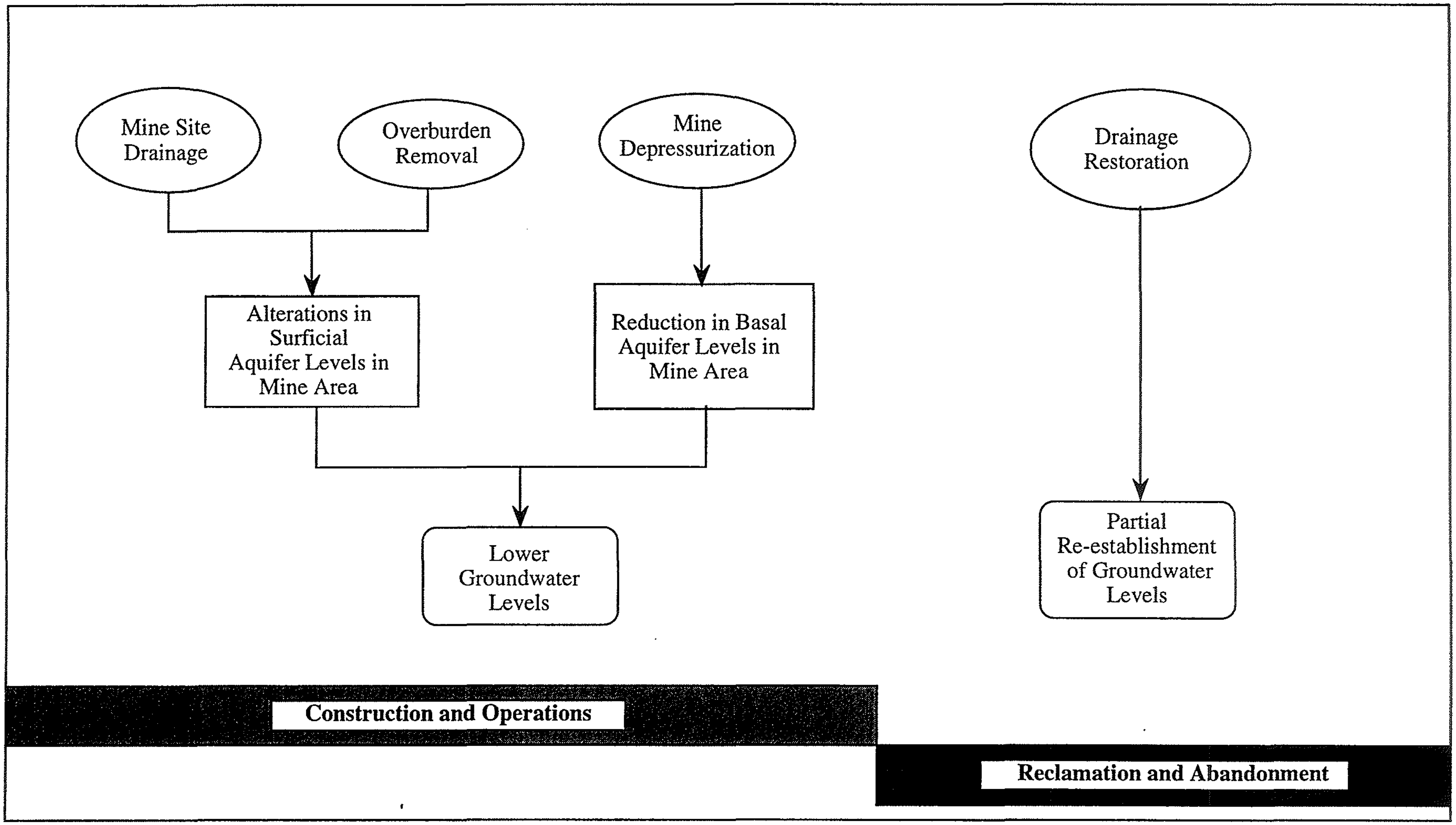
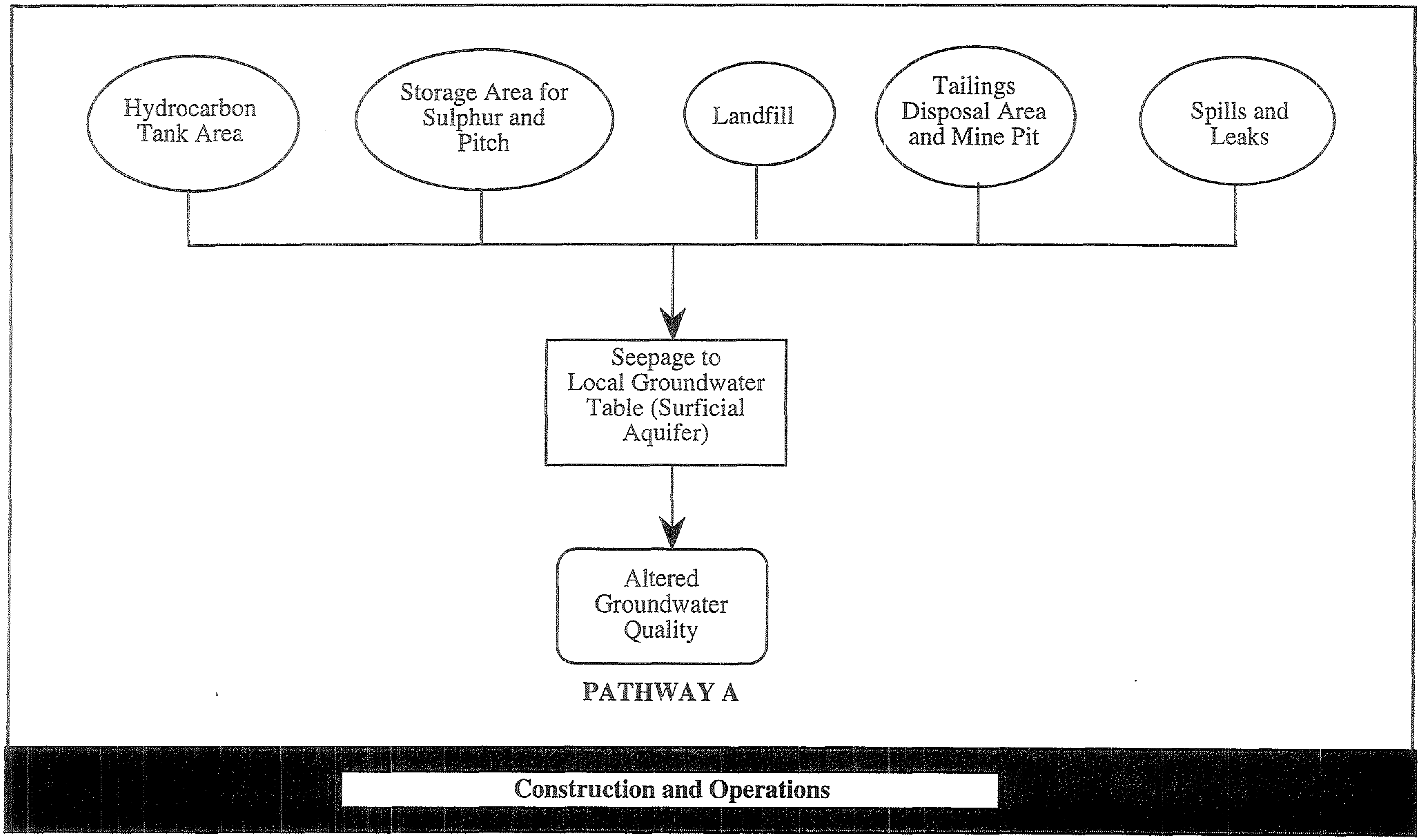


Figure 5.18 **The hydrocarbon tank area, Tailings Disposal Area, landfill and storage piles can alter *groundwater quality*.**



5.4.2 *Effects on Groundwater Levels*

The potential impacts on groundwater levels and the significance of these effects on each aquifer are summarized in Figure 5.17. Mine development in the area will impact the groundwater levels of the area. Specifically:

- During the construction and operations phase, on-site drainage using surface trenches in the mine area may be required prior to mine development. A perimeter ditch will be constructed around the plant site to ensure dry operating conditions. This on-site drainage may have an impact on the surficial aquifers in the vicinity of the mine and plant site, likely lowering their levels to the depth of the drainage trenches for the Life of the Operation. This impact should be reversible during post-mining.

- The removal of overburden material, which will include the surficial aquifer during the operations phase, may impact the mine area groundwater levels. The perched water table in the surficial aquifer will be drained and removed during overburden removal. This will lower the groundwater level to the top of the McMurray Aquifer (Oil Sands). If the natural overburden material is used for backfilling, this impact should be reversible during post-mining.

- If mine depressurization is required during the operations phase, the natural groundwater level in the mine areas will be impacted. Mine depressurization would lower the groundwater level to the base of the oil sands. This could be a long-term, irreversible impact on the groundwater levels of the Lease 5 area.

- The proposed mine plan is to backfill the mine with the wash sand and cover the sand with salvaged overburden materials. Once depressurization and the surface drainage trenches are discontinued and the mine is backfilled, the groundwater levels will start to recover. However, since the wash sand is more permeable than the original overburden, the effects of the groundwater level is irreversible and the post-mining groundwater level in the vicinity of the mine could be lower.

Alberta Environmental Protection well records indicated only one water well within 5 km of the mine area (i.e., 06-20-95-10-W4M). Discussions with the Alberta Forest Service (Chris Hale, Alberta Forest Service, pers. comm.) indicates that there is no foreseeable use of this well, therefore, groundwater level impact should not impact any groundwater users of the region.

It is proposed that the mine area be backfilled with wash sand and natural overburden material. Groundwater levels in the overburden should re-established to pre-mining conditions; however, the water level in the McMurray and McMurray Basal aquifer will be lowered due to mining activities.

5.4.3 *Effects on Groundwater Quality*

Potential effects on groundwater quality during the Life of the Operation and Post-Operations are summarized in Figure 5.18. There is the potential for seepage of contaminants from the hydrocarbon tank area, the tailings disposal area, landfill and storage piles. The operations plan for the site is being developed, and at present storage piles will include bitumen, sulphur and pitch.

- The hydrocarbon tank storage area will be dyked and surface runoff will be diverted to a lined surface drainage retention pond. It will be released to the plant perimeter ditch if it meets AEP requirements, or directed to the process make-up system. Seepage of some contaminants through the ground surface could reduce groundwater quality.

- Tailings sand from the extraction process is expected to be inert in composition, because of Solv-Ex's patented extraction process. However, seepage of hydrocarbons from the tailings disposal area could reduce the surficial groundwater quality within a limited area.

- There should be no potential of contamination of groundwater from the pitch or sulphur storage piles. Pitch and sulphur will be stored on clay-lined or concrete/asphalt ground pads. Surface and subsurface drainage from these two storage sites will be collected and routed to the lined surface drainage retention pond. It will be released to the plant perimeter ditch if it meets AEP requirement, or directed to the process water make-up system.

- Garbage will be compacted and transported by truck to an AEP approved landfill. Over the longer term, Solv-Ex may make a separate application under AEPEA for an on-site industrial landfill, but it would be designed to meet AEP guidelines and should not affect groundwater quality.

- Spills or leaks during plant operation could affect groundwater quality. Solv-Ex will join the Area "Y" Environmental Co-operative, which will make the oil spill containment and clean-up resources of the co-operative available to handle any emergencies. Employees will be trained in emergency spill response, and clean-up materials will be stored on-site. These measures should minimize groundwater contamination due to spills or leaks.

- Seepage of hydrocarbons present in the tailing sand that will be placed in the mine pit should not reduce the basal groundwater quality because these aquifers are exposed to hydrocarbon-bearing formations.

5.4.4 *Summary of Residual Impacts*

The residual impacts of the Solv-Ex Experimental Co-production project on groundwater quantities during the Life of the Operation and after abandonment (Post-Operations) are described below.

Due to protection measures Solv-Ex will implement, there is low potential for groundwater contamination from the pitch and sulphur storage sites, the potential landfill or tailings disposed of in the mine pit.

Life of Operation:

- In the vicinity of the mine and plantsite, there will be a reduction in groundwater levels in the shallow and the upper Cretaceous aquifers. This impact is considered Moderate in magnitude, as the water level will be reduced to the mine base, Negative, Long-term, Continuous, Local in spatial extent, Irreversible during the mining operation.

- There will be a reduction in groundwater levels in the basal aquifer, where present, if mine depressurization is required. This impact is considered High in magnitude, Negative, Long-term, Local, Continuous during mining activities, and Irreversible in the vicinity of the mine as oil sand is replaced with wash sand.

- If seepage of hydrocarbons from the hydrocarbon tank area or the tailings disposal area occur, groundwater quality may be impacted in a limited area. This impact is considered Low to Moderate in magnitude, Negative only if seepage occurs, Short-term if seepage is identified and mitigated, Continuous, Local, and Reversible if seepage is identified and mitigated.

Post-Operation:

- As drainage patterns are re-established and the end-pit lake is filled, groundwater tables in the mine and plant site areas will be restored to pre-development levels, except in the vicinity of the end-pit lake and mined area where the water table is expected to stabilize at lower than pre-disturbance levels. This impact is considered Positive and Long-term, (other impacts terms are not applicable).

5.4.5 *Groundwater Monitoring*

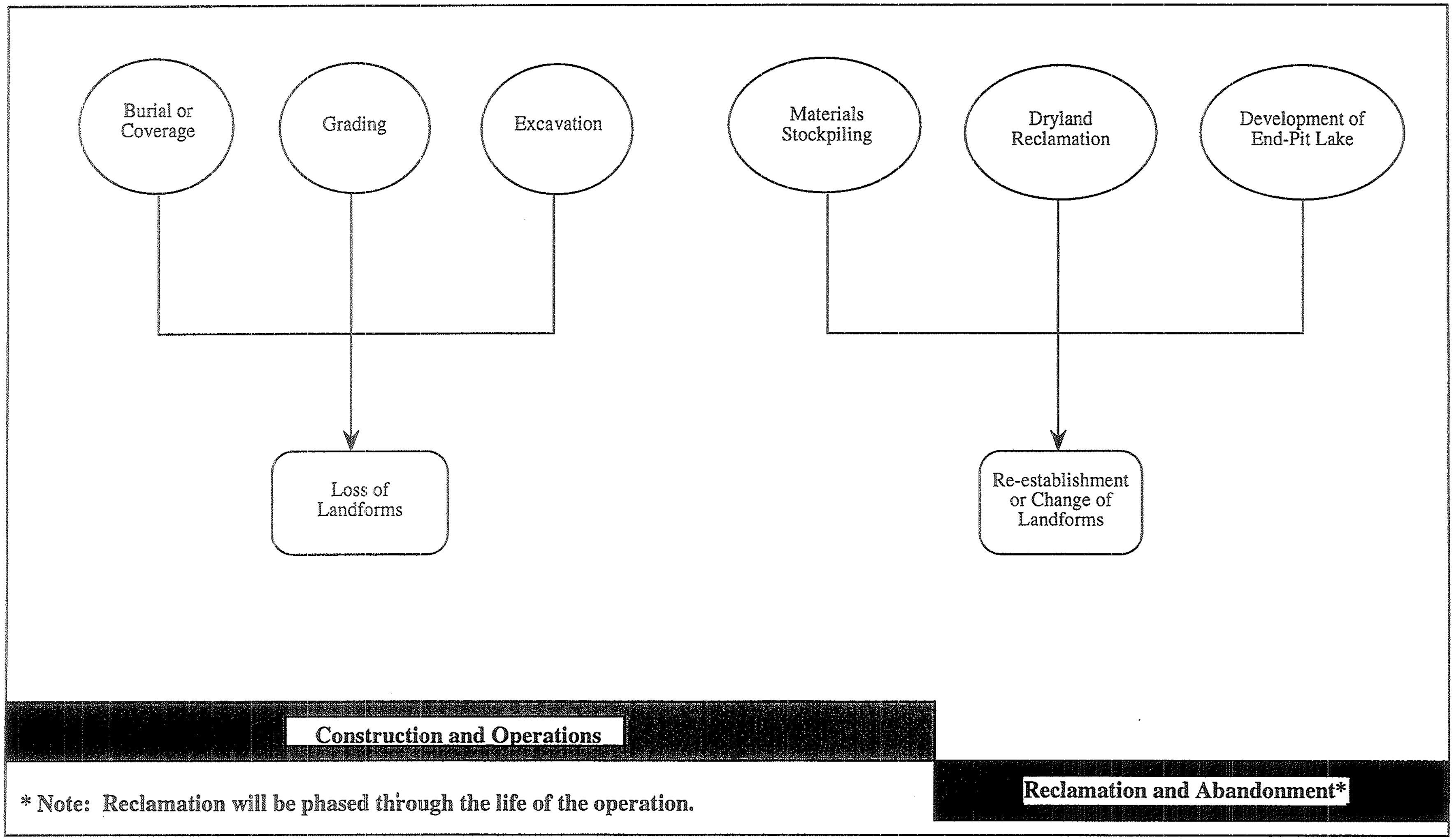
Monitoring wells will be installed at the Lease area to monitor potential impacts on the underlying groundwater quality and changes in groundwater levels. The monitoring program will be designed to meet the requirements outlined in the Clean Water Licence to Operate.

5.5 Terrain, Geology, Soils and Overburden

5.5.1 *Terrain and Geology*

Activities associated with the Solv-Ex development that will affect terrain and geology are summarized in Figure 5.19. Landforms will be altered during the construction and operations phase, as geological materials are excavated, buried by materials, or covered by facilities. At abandonment, backfilling of former mine area, contouring of above-grade disposal areas and stockpiles, and dryland reclamation will re-establish new landforms that are consistent with the surrounding landscape.

Figure 5.19 Burial or coverage, grading or excavation or stockpiling will result in the loss of landforms during construction and operations. Development of an end-pit lake and dryland reclamation will *re-establish or change landforms* during the reclamation and abandonment phase.



Over the life of the operation, the total area of landforms disturbed associated with the Solv-Ex Development will be 331 ha. Area of landforms affected by the project in the LSA are summarized in Table 5.12 while the disturbances in the BCESA are summarized in Table 5.13. Within the BCESA, a total of 159 ha, or <1% of the landforms, have been previously disturbed due primarily to cutlines and wellsites. The cumulative effect of disturbing landforms for the Solv-Ex project is 490 ha or 1% of the landforms in the BCESA.

After vegetation clearing, materials handling for the Mine will begin. Established regional practices will be followed:

- Prior to overburden removal, sufficient materials suitable for use in reclamation, including muskeg, will be salvaged and stockpiled temporarily.

- Overburden will be stored initially in the external mine waste area until year 3 of mining when overburden will be disposed in-pit. Overburden removal activities will be undertaken progressively, as mining of the orebody proceeds.

- The oil sand ore will be excavated from the McMurray Formation over an area of 50 ha (Table 5.12).

Site preparation for plant facilities and infrastructure and storage site, will be carried out in the first few years of the project, resulting in a loss of landforms for the duration of the operational phase of the project.

- Plant site, top soil storage and access roads will result in temporary burial or coverage of 53 ha landforms (Table 5.12).

- Pipelines will result in temporary linear excavation affecting 23 ha of landforms (Table 5.12).

- Upgrading of Highway 63, external tailing disposal and mine waste areas will result in the permanent burial of 164 ha of landforms (Table 5.12).

- Post operation there will be a permanent loss of 14 ha of landforms from the Highway 63 upgrading. In addition, there will be a change in landform type with the development of the 30 ha end-pit lake.

Changes to landforms from prior previous activities in the Local Study Area (LSA) totals 411 ha (airstrip, gravel pits, well sites, pit liner).

As a result of the Solv-Ex project, there will be 146 ha of new landforms developed, consisting of 30 ha of an end-pit lake and 150 ha of tailings and waste dumps.

Table 5.12 Disturbance of geologic materials as a result of the Solv-Ex Development.

Facility	Type of Disturbance	Area to be Disturbed (ha)
Mine	Excavation	50
Natural Gas Pipeline, Water Pipeline	Temporary Linear Excavation	23
Other Areas Cleared	Grading	41
Plant Site, Topsoil Storage Area, Access Roads	Temporary Burial or Coverage	53
Highway 63, External Mine Waste Area, External Tailings Disposal Area	Permanent Burial	164
TOTAL		331

Table 5.13 Disturbances to landforms in LSA and BCESA.

	Disturbances Local Study Area	Disturbances BCESA
Existing	37 ha	159 ha
Solv-Ex Project	331 ha	331 ha
Total (including Solv-Ex)	368 ha	490 ha
% of Total Study Area[a]	8%	1%

[a] Area of LSA 4425 ha and BCESA 54 475 ha.

In summary, geologic materials and landforms within an area of 331 ha will be affected by burial or coverage, grading and excavation. This represents an disturbance of 7% of the Local Study Area and 0.6% of the Cumulative Effects Study Area.

Potential for erosion of recontoured disposal areas and other reclaimed upland sites will be mitigated by revegetating disturbed areas as soon as feasible after construction. Geologic materials in the mine area, removed during reclamation materials stripping, overburden removal and mining, will be replaced at abandonment with overburden and lean oil sand placed in-pit during the later stages of mining.

Mitigation will be undertaken by reclaiming 317 ha out of 331 ha of disturbed land (96%) to landforms compatible with the surrounding environment and to meet AEP reclamation guidelines, both during the operation and following project abandonment (after 7 years).

5.5.1.1 Summary of Residual Impacts

The impacts of the Solv-Ex Experimental Co-production project on landforms during the life of the operation and post-operation are summarized below.

Life of Operation:

- There will be a progressive disturbance of 331 ha of landforms during the 7 year operating period of the Solv-Ex project. During operation, reclamation will have been initiated on 20 ha of the mine to re-establish landforms. This disturbance represents 7% of the LSA (Moderate magnitude) and 0.6% of the CESA.

- There will be a temporary disturbance of 67 ha of landforms during the 7 year operating period of the Solv-Ex project. The temporary impacts during operation will be Negative, Moderate in magnitude, Moderate in Duration, Continuous, Local and Reversible.

- There will be a permanent burial of 164 ha of landforms during the operation of the Solv-Ex project. These impacts will be Moderate in magnitude, Negative, Long-term, Once, Local and Irreversible.

Post-Operation:

- There will be a re-establishment of 137 ha of landforms (mine area, access roads, pipelines and plant sites that are similar to the pre-existing landforms). These impacts will be Positive, Moderate in magnitude, Long-term, Once, Local and Irreversible.

- There will be 180 ha of new landforms created due to the end-pit lake and waste disposal areas. These impacts will be Moderate in magnitude, Neutral, Long-term in duration, Once, Local and Irreversible.

- There will be a permanent loss of 14 ha due to the Highway 63 upgrade. These impacts will be Low in magnitude, Negative, Long-term, Once and Irreversible.

5.5.2 *Soils and Overburden*

Types of activities associated with the Solv-Ex development that could affect soils and overburden are summarized in Figure 5.20. In total there will be 331 ha of soils in the Local Study Area disturbed during the Life of Operation. This represents 7% of the Local Study Area. These disturbed areas will be impacted by:

- Site drainage
- Soil erosion
- Soil mixing and burial
- Soil compaction
- Spills/leaks and leaching
- Soil reclamation

Table 5.14 summarizes the soil types that will be disturbed from the development. The major soils that will be disturbed are the Kenzie 2 and the Mildred 1 with areas of 187 ha and 100 ha, respectively. Note that Kenzie 2 and Mildred 1 soils have an agricultural capability of 7 and 5, so no prime land will be disturbed.

The disturbance from the Solv-Ex project of 331 ha represents an increase of 7% (Table 5.15) in the LSA and 0.6% in the BCESA.

Within the BCESA, a total of 2385 ha or 4% of the soils has been previously disturbed due to cutlines and wellsites. The cumulative effect of disturbing soils for the Solv-Ex project will be 2716 ha or 5% of the BCESA.

Of the total disturbance in the LSA of 331 ha, only 44 ha will not be able to be mitigated by reclaiming the land to equivalent agricultural capability. Note that 14 ha of permanent loss will be under the jurisdiction of Alberta Transportation and Utilities due to the Highway 63 upgrade and 30 ha will be from the end-pit lake.

5.5.2.1 Factors That Could Decrease Soil Capability

Soil Erosion

Movement of soil by heavy equipment will most likely result in the loss of a portion of the soil resource through erosion. Soils will be exposed to both wind and water erosion during salvage, transport, replacement and storage resulting in soil loss.

Figure 5.20 **Site clearing, facility construction, overburden removal and storage, material disposal, site drainage, spills and leaks, SO_2 emissions, could *decrease soil capability*. Soil restoration will *re-establish soil capability*.**

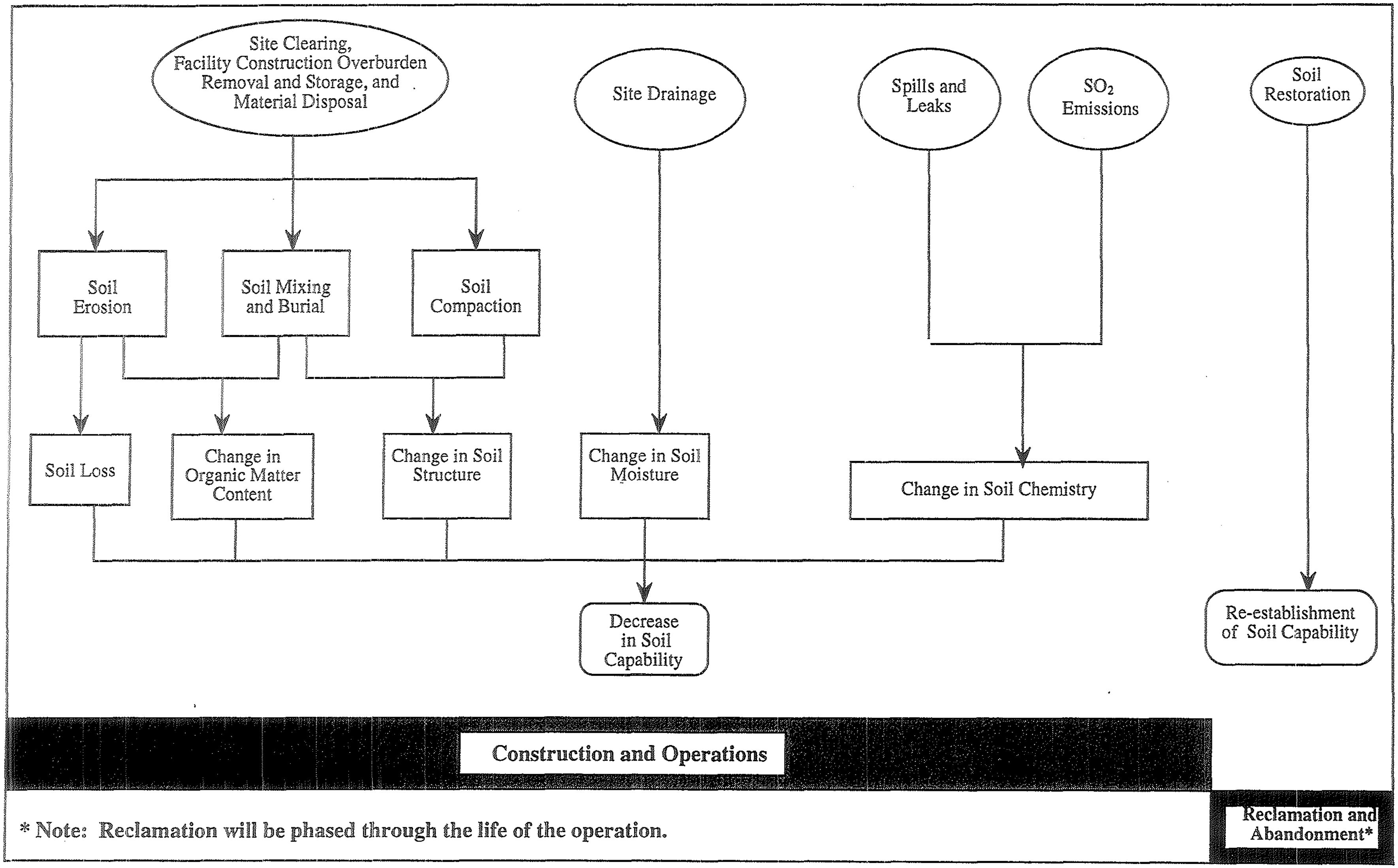


Table 5.14 Area of Soil Associations Disturbed in the Local Study Area by the Solv-Ex Project.

Soil Associations	Area Disturbed (ha)	% of Total	% of LSA	Area in Local Study Area (ha)	Soil Capability for Agriculture
Mildred 1	100	30	2	2217	5
Mildred 2	1	< 1	< 1	103	5
Haight	2	< 1	< 1	181	5
Bitumount	37	11	< 1	437	6
Buckton	1	< 1	< 1	50	5
KNZ1	2	< 1	< 1	214	7
KNZ2	187	57	4	601	7
TOTAL	331	100	7	3803	NA

NA - Not Applicable.

Table 5.15 Disturbances in the Local (LSA) and Biophysical Cumulative Effects Study Areas (BCESA).

	Disturbances in Local Study Area	**Disturbances in BCESA**
Existing Disturbances	411 ha	2385 ha
Disturbance due to Solv-Ex Project	331 ha	331 ha
Total Disturbances (including Solv-Ex)	742 ha	2716 ha
% of Total Study Area[a]	17	5

[a] Area of LSA 4425 ha and CESA 54 475 ha.

Soil erosion from mining is primarily the result of vegetation removal and disturbance of surface soil structure. Erosion by water is likely to be of greater significance than that of wind in the area due to low wind speeds, forested areas that provide a buffer, a wind breaking effect and inherent soil moisture that holds the soil particles together (Hausenbuiller 1985).

In addition to removal of vegetation, construction activities are likely to eliminate a large portion of the surface organic layers and reduce mineral soil aggregate stability. Steeper slopes associated with the overburden disposal areas will also enhance the potential for erosion.

Since disturbed storage areas will be vegetated to prevent erosion, and the Mildred soils are coarse-textured and the Kenzie soils are high in organic matter, erosion is not expected to significantly reduce soil capability.

Soil Mixing and Burial

Topsoil and subsoil mixing, also called admixing, will result from the removal of vegetation, overburden removal and construction activities. Salvage of suitable reclamation materials will be undertaken by truck and shovel, scrapers and/or dozers. During soil salvage, overstripping or understripping (whether it be due to operator error, equipment inadequacies or horizon depth variability) will result in soil mixing. Soil mixing as a result of soil handling and construction has been well documented for pipelines (Hardy Associates (1978) Ltd. 1983) and for mining (Macyk 1986).

Soil mixing, burial and loss will dilute organic matter content and decrease the soil capability. Organic matter is positively correlated with water retention and nutrient supply and thus with soil fertility (Hillel 1971). As organic matter content increases, Cation Exchange Capacity (CEC), a measure of inherent fertility and therefore capability, also increases, thus a decrease in organic matter content can decrease the soil's capability.

Since the organic horizons of Kenzie soils will be salvaged for use in reclamation, and the topsoils of the Mildred soils are naturally low in organic matter, soil mixing and burial is not expected to significantly decrease soil capability.

Soil Compaction

Soil compaction by forestry equipment in Alberta has been documented to persist for decades (Corns 1988). Compaction reduces pore space and, therefore, air and water permeability, rooting space and soil infiltration rates which results in higher erosion potential.

Heavy equipment traffic creates ridges and ruts that mix and compact soil horizons. This form of soil mixing has been observed for both pipelines (Hardy Associates [1978] Ltd. 1983) and exploration and coal mining (Bateman 1992). This type of compaction would be of greatest concern in the placement of the reclamation capping material (Kenzie soils). Since the soil can be disced or deep ripped after placement and the salvaged soil are generally coarse textured, the impact of this type of compaction can be mitigated, and a reduction in soil capability should not occur.

Site Drainage

Surficial deposits, predominantly organic soils, will be drained to allow for clearing and subsequent removal of reclamation materials at the mine and plant sites. Drainage will be accomplished by finger and perimeter ditches, and waters will be directed to a holding pond. Drainage of the Kenzie and Bitumount soil types will increase soil capability. Mildred soil types will not require drainage.

Spills, Leaks and Leaching

The addition of potentially deleterious substances to the soil resource is possible through:

- spills of hydrocarbons,
- seepage from the external mine waste dump and the external tailings disposal area, and
- wind blown dust from sulphur block.

Hydrocarbons from spills or leaks can persist in the soil for long periods of time and affects soil aeration, carbon/nitrogen ratios and organic matter cycling. Any hydrocarbon spills will likely be confined to the plant site. Spills will influence very small areas and will be immediately cleaned-up, so are not expected to influence soil capability.

The external mine waste dump to be established east of the plant site is likely to contain the saline and sodic Clearwater formation. Seepage from this disposal site may affect the surrounding undisturbed Mildred soil types. Experience with similar overburden disposal areas at other mines in the area has shown no seepage of saline/sodic water, therefore, seepage should have no impact on the soil capability surrounding Mildred soils.

Since no hydrocarbon fumes or seepage is expected from the external tailings disposal area, or the pitch storage area, there should be no impact on soil capability from these facilities.

Sulphur will be stored in block form for 1 to 2 years prior to the startup of the mineral extraction plant. Some sulphur may be spread to surrounding soils by the wind. The design of sulphur block storage facilities are regulated by the AEUB (IL 84-11, GB 92-4) and Alberta Environmental Protection. Elemental sulphur is broken down in the soil to sulphuric acid, resulting in the acidification of the soil. The content of wind blown sulphur around some storage areas in Alberta has been reported to be over 20%, with the growth of grasses being reduced at sulphur contents greater than 4% (Leggett and Parkinson 1988).

Once the mineral extraction plant is operational, there will be a net deficit of sulphur required for the process. Sulphur will be trucked in liquid form and stored in a 4800 t capacity tank within a bermed asphalt containment area. Since elemental sulphur will only be temporarily stored in block form, the area subject to soil acidification should be small since the construction of the storage area will meet AEUB requirements. The effect on soil capability will be insignificant.

The planned quick spill response and cleanup will mitigate a large degree of any impact. Clean-up response will be maintained on-site. The residual impacts are expected to be of a minor nature in the long term.

SO_2 Emissions

The SO_2 deposition modelling results presented in Section 5.1 summarize the predicted Effective Acidity values in the Local Study Area (LSA) and Air Resources Cumulative Effects Study Area (ARCESA) (Figures 5.3 to 5.11). The three cases that we have used in our analyses to determine the potential for soil acidification include:

- Future Syncrude and Suncor emissions,
- Solv-Ex emissions alone, and
- Solv-Ex emissions combined with future Syncrude and Suncor emissions (cumulative effect).

Alberta Environment (1990) has set interim acid deposition target loadings to protect soils from acidification. The Effective Acidity (EA) deposition limits are based on a 10% reduction in base saturation over a 100 year loading period. Based on these guidelines, it has been assumed that highly sensitive soils receiving between 0.1 and 0.3 kmol H^+/ha/a are potentially at risk of acidification, and those receiving > 0.3 kmol H^+/ha/a are at risk of acidification over a 100 year loading period. Additionally, moderately sensitive soils receiving 0.3 to 0.4 kmol H^+/ha/a and low sensitive soils receiving 0.7 to 1.0 kmol H+/ha/a are also potentially at risk of acidification (Section 4.1.4.2).

The maximum predicted Effective Acidity (EA) resulting from the SO_2 emissions from the Solv-Ex plant (Table 5.16; Figure 5.7) alone is 0.14 kmol H^+/ha/a located about 1.8 km south of the proposed plant. The maximum EA including the Solv-Ex and future Syncrude and Suncor emissions is 0.28 kmol H^+/ha/a locate 53 km to the south-southeast of the Solv-Ex plant. The Solv-Ex plant does increase the acidifying potential in the immediate vicinity of the proposed plant site, where the maximum combined value of 0.20 kmol H+/ha is reached (Figure 5.7).

While about 25% of the soils in the LSA are rated as highly sensitive to acidic deposition (Table 4.13, Kenzie and Firebag soils), the short time frame of operation of the Solv-Ex plant (6 years), and the fact the maximum EA will not exceed the 0.3 kmol H^+/ha/a deposition loading for highly sensitive soils, indicates there will be no significant soil acidification in the LSA.

Figures 5.6 and 5.8 show that on a regional basis, Solv-Ex will have an insignificant impact on regional soil acidification. In the ARCESA, there will be a 6% (1011 km^2) increase in soils exposed to an EA of > 0.1 kmol H^+/ha/a and no increase in the area with an EA > 0.3 kmol H^+/ha/a. While there are soils highly sensitive to acidification in the ARCESA, the contribution of the Solv-Ex plant over a 6 year period will be insignificant.

Table 5.16 Maximum Predicted Effective Acidity Values.

Operating Facility	**Maximum EA ($kmol H^+/ha/a$)**	**Area (km^2) > 0.1 kmol $H^+/ha/a$**	**Area (km^2) > 0.3 kmol $H^+/ha/a$**
Solv-Ex Plant	0.14	227	0
Future Syncrude and Suncor Plants	0.28	16 379	0
Solv-Ex, and Future Syncrude, Suncor Plants	0.28	17 390	0
Percent Increase in Area Under Contours	0	6	0

Note that this conclusion is further supported by research reported by Cheng *et al.* (1995). In this research, they found that the predicted background EA for Fort McMurray according to computer modelling was 0.09 while the calculated value was 0.04. This suggests that the modelling results can overestimate the EA in the Fort McMurray area even though it is located close to 2 major emission sources.

5.5.2.2 Re-establishment of Soils

Of the 331 ha of soils to be disturbed during the 7 year operating period of the Solv-Ex project, 32% have a soil capability of Class 5 (Mildred, Haight, Buckton), 11% Class 6 (Bitumount) and 57% Class 7 (Kenzie). Solv-Ex will re-establish an equivalent distribution of soil capabilities at project abandonment as exists currently. However, the soil capabilities will not necessarily be equivalent in each area disturbed.

Soils will be re-established using the following procedures:

- About 20 ha within the mine area will eventually have a minimum of 50 cm of reclamation material on the surface. The surface material is likely to be a mixture of peat (muskeg) and mineral material, and will have equivalent capability as pre-disturbed soils.

- The 53 ha plant site, access roads and topsoil storage areas will be reclaimed as per AEUB requirements. The equipment will be removed and a minimum of 30 cm of previously salvaged surface soil will be replaced to allow for revegetation.

- The 41 ha at cleared area around facilities (Table 2.1) will be reclaimed by the placement of a minimum of 15 cm of surface soils for reclamation.

- The 156 ha area of the external mine waste dump and the external tailings disposal area will be contoured and capped with a minimum of 30 cm of surface soil to create a rooting medium for vegetation.

- The 23 ha of temporary pipeline right-of-ways will be reclaimed by following AEP reclamation standards for pipelines. A minimum of 2 lifts of soil will be salvaged to quickly re-establish soil capability in these areas.

Within the overburden removal area for each calendar year, the best reclamation material available will be salvaged first to fulfill the requirements for direct placement. These procedures will provide conditions acceptable for tree growth and attaining the planned end-land uses in the region.

Restoration of soil capability required to meet the end-land use objective is likely to be attained due to the categorization of salvaged materials and subsequent amendment with peat materials.

Traditionally in oil sands operations Kenzie soil types, as well as the other organic soils, have been used as amendment materials to overburden to improve moisture holding capacity, organic matter content and soil fertility of the reconstructed growth medium (HBT AGRA 1992). In locations where Kenzie soils are shallow enough to permit incorporation of underlying mineral material during salvage, the resultant mixture will most likely rate as a fair reclamation medium.

The soil capability of reclaimed soils will likely be similar to the pre-disturbance condition after a sufficient time period for reclamation.

5.5.2.3 Summary of Residual Impacts

The impacts of the Solv-Ex Experimental Co-production project on soil capability during the Life of the Operation and Post-Operation phases are summarized below.

Soil erosion, soil compaction, spills and leaks and SO_2 emissions will result in negligible changes in soil capability in the LSA.

The increase in acidifying emissions from the Solv-Ex project is not predicted to change the quality of soils in the region. Information on the sensitivity of soils contained within Effective Acidity contours that exceed the target loadings (representing the SO_2 emissions from the Solv-Ex plant and from the Solv-Ex and future Syncrude and Suncor plants) and the short duration of SO_2 emissions from the Solv-Ex plant (6 years), indicates that the soils should not be at risk of acidification.

Life of Operation:

- A total of 331 ha of soils will be disturbed during the 7 year operational phase of the Solv-Ex project. This represents a 7% increase in disturbance in the Local Study Area and 5% increase in the Biophysical Resource Cumulative Effect Study Area. Soil capabilities will be decreased through soil mixing and burial. Reclamation will restore 287 ha back to equivalent soil capabilities. There will be permanent loss of 44 ha of soils disturbed due to the Highway 63 upgrade and the end-pit lake. These residual impacts due to soil mixing and burial will be Negative, Moderate in magnitude, Moderate-term, Continuous, Local, Reversible and Irreversible.

- Drainage of soils prior to site development will be required for the Organic and Glysolic soils. Drainage will improve the soil capability.

Post-Operation:

- Reclamation will restore soil capability on 287 ha of the disturbed areas. About 44 ha of soils will be permanently lost due to the Highway 63 upgrade and the end-pit lake. This residual impact will be Low in magnitude, Negative, Long-term, Once, Local and Irreversible.

5.5.2.4 Soil Monitoring

Solv-Ex will monitor the progress of reclamation throughout the Life of the Project. Baseline soil and overburden sampling and analyses has been undertaken. Solv-Ex plans to continue the analyses and evaluation of the mine and other disturbed areas for:

- pH
- Electrical conductivity
- Saturation percentage
- Sodium adsorption ratio
- Particle size analyses
- Soil structure
- Reclamation suitability of horizons.

On reconstructed soils, a detailed evaluation of the above parameters will be undertaken to aid in choosing appropriate vegetation seed mixes.

Soil chemical and physical characteristics will be analyzed periodically to aid in judging reclamation success. Particular attention will be paid to evaluating soil filth, as good soil chemistry (low SAR) is not always an assurance that soil physical properties will not limit reclamation success.

5.6 Vegetation Impacts

Activities associated with the Solv-Ex development that could affect vegetation are summarized in Figure 5.21. Plant communities could be lost, due to clearing or fires, or altered due to changes in plant vigour or increased plant mortality. The potential effects of spills of products or chemicals from trucks on vegetation along the transportation route have not been discussed here because of its low probability and likely limited areal extent.

5.6.1 *Loss of Plant Communities*

Development of the Solv-Ex project will result in the clearing of 296 ha of vegetation within Lease 5 for the mine, overburden disposal areas, roads and plant site, and 35 ha within the existing right-of-way for the road upgrade and pipeline construction. There has already been over 400 ha of vegetation disturbed in the LSA (10% of the area), due to previous activities, particularly clearing of the Highway 63 right of way and cutlines (Table 5.17). Vegetation cleared for this development represents a 7% increase in the disturbed vegetation within the Local Study Area, or a <1% increase in cleared area within the Biophysical Cumulative Effects Study Area (Table 5.17). Within the BCESA, a total of 2385 ha or 4% of the vegetation has been previously disturbed due primarily to cutlines and wellsites. The cumulative effect of clearing vegetation for the Solv-Ex project will be 2716 ha or 5% of the BCESA.

Figure 5.21 Site clearing, forest fires, air emissions, changes in drainage patterns, changes in soil capability and changes in water quality will affect plant growth which will lead to a *change in the structure and diversity of plant communities*. Reclamation will *re-establish plant communities.*

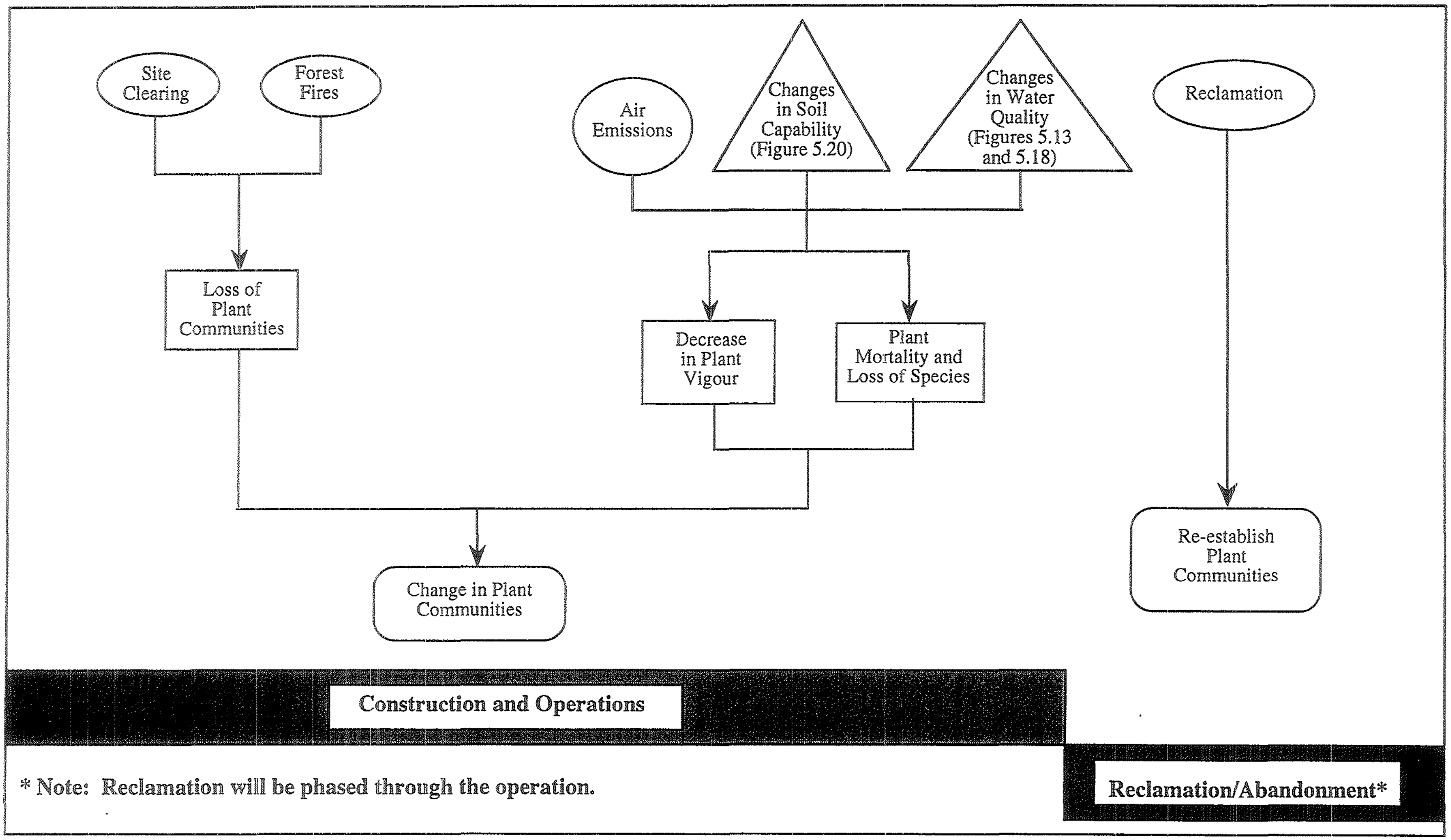


Table 5.17 Vegetation Disturbed in the Local and Biophysical Cumulative Effects Study Areas.

Type of Disturbance	Local Study Area (LSA)[a]		Biophysical Cumulative Effects Study Area (BCESA)[a]	
	Area (ha)	Percent of Area (%)	Area (ha)	Percent of Area (%)
Gravel pits	11	< 1	11	< 1
Bitumount airstrip	12	< 1	12	< 1
Highway 63 (right-of-way or paved road)	210	5	300	< 1
Barge landing site	4	< 1	4	< 1
Bitumount historic site	10	< 1	10	< 1
Wellsites and cutlines	164	4	2016	4
Village of Fort McKay	-	-	32	-
Subtotal of Existing Disturbance	**411**	**10**	**2385**	**4**
Proposed Solv-Ex Development	331	7	331	< 1
TOTAL	**742**	**17**	**2716**	**5**

(a) Area of the LSA and BCESA are 4425 ha and 54 475 ha, respectively.

The areas of vegetation communities and forest cover types to be cleared are provided in Table 5.18. The dominant vegetation communities that will be cleared in decreasing order of abundance are: black spruce forest (57%), fen (11%), aspen forest (10%), aspen/jack pine forest (8%) and white spruce forest (3%). This includes 48 ha of early successional vegetation within the previously cleared utility corridor. No old-growth forest will be affected by the clearing.

Clearing of vegetation may lead to windthrow or blowdown effects in the surrounding forest. Spruce, especially black spruce, is susceptible because it is shallow rooted. Most windthrow occurs within the first 5 year following clearing in a strip 30 m from the opening (Fleming and Crossfield 1983). Blowdown of trees around the Syncrude Project Area has been infrequent (Dabbs Environmental Services and Nichols Applied Management 1987), and thus this effect should be minor.

No rare plants will be affected by vegetation clearing for the Solv-Ex project. During the field inventory in June 1995, no rare plants were located within the proposed development area. Alder-leaved buckthorn, an uncommon plant in Alberta, was located in two areas that will be disturbed. Because this plant is located throughout the region, it is felt that the Solv-Ex development will have a limited impact to this species.

Riparian vegetation in the region includes McLelland Lake, the Athabasca River and Fort Creek. McLelland Lake and its associated wetlands are not within the area that will be influenced by the Solv-Ex development. Riparian shrub communities associated with Fort Creek will not be disturbed. The Athabasca River vegetation communities will not be disturbed, except for <1 ha in the vicinity of the water intake. The setback for the preferred mine from the Athabasca River is 50 to 100 m (Section 1.4).

Forest fires are a common disturbance of the vegetation communities within the northeastern region of Alberta (Delisle and Hall 1987). The maximum return cycle for fire within the Solv-Ex development area is currently approximately 150 years based on tree ages (Phase 3 Forest Cover Maps). Most forest stands are younger, indicating that the fire return cycle is considerably shorter than the maximum.

Clearings within forest stands are used to prevent or control fire start, escape and spread. Clearings will be established to control and suppress fire, and will provide sufficient fuel break between the plant and mine sites to reduce the potential of a fire starting from the Solv-Ex operation.

5.6.2 *Decrease in Plant Vigour and Plant Mortality and Loss of Species*

Plant vigour could be reduced by changes to site drainage, changes to water quality, soil acidification or increased SO_2 concentrations caused by the Solv-Ex project. Continued exposure to factors that cause reduced vigour, eventually could result in the mortality of plants and a loss of species most sensitive to the effects.

Table 5.18 Areas of Vegetation Communities and Forest Cover Types in the Local Study Area affected by the Solv-Ex Project.

Vegetation Communities and Forest Cover Type	Area Disturbed (ha)	% of Total	% Change of LSA	Area[a] of Local Study Area (ha)
White Spruce Series				
White spruce	3	1	1	472
Aspen	32	10	4	762
Aspen/White spruce	3	1	1	241
Aspen/Jack pine	25	8	12	203
Jack pine/Aspen	0	0	0	199
White spruce/Aspen	3	1	3	90
Jack pine/White spruce	0	0	0	18
White spruce/Black spruce	0	0	0	12
Black spruce/Aspen	0	0	0	11
Jack Pine Series				
Jack pine	1	<1	<1	248
Black Spruce Series				
Black spruce	190	57	20	939
Black spruce/Jack pine	0	0	0	103
Jack pine/Black spruce	0	0	0	188
Bog Types				
Blanket Bog	0	0	0	257
Slope Bog	0	0	0	28
Bowl Bog	0	0	0	7
Shrub and Grasslands				
Shrub	0	0	0	21
Bitumount airstrip	1	<1	8	12
Road clearing (early successional vegetation)	36	11	17	210
Fen Types				
Fen	37	11	12	304
Anthropogenic Types				
Gravel pits	0	0	0	11
Bitumount historic site	0	0	0	10
Barge landing site	0	0	0	4
Other Types				
Steep slopes	0	0	0	34
Water	0	0	0	41
TOTAL	**331**	**100**	**n/a**	**4425**

[a] The areas of cutlines and wellsites are not separated from individual forest cover types.

5.6.2.1 Drainage and Soil Capability

There will be some alteration of on-site drainage patterns resulting from mining operations, diversion ditches and construction of the plant site, tailings and overburden piles and roads.

- Drainage will be improved over about 10 ha outside the perimeter ditch surrounding the plant site, and in the vicinity of the mine due to dewatering of surface aquifers.
    - Aspen/jack pine communities in the vicinity of the mine will not be affected by these drainage alterations.
    - Black spruce and bogs in the vicinity of the plant site and/or mine could change in species composition, as plant species adapted to wetter conditions decline in vitality and abundance, and those adapted to drier conditions become established.
    - Mosses and water-loving shrubs and herbs such as crowberry and bog cranberry usually decline following drainage, whereas taller shrubs and trees such as willow, alder, aspen and spruce tend to increase in abundance (Hillman *et al.* 1990). Hillman *et al.* (1990), Lieffers (1988) and Lieffers and Rothwell (1987) found that drawdown on peaty soil increased potential for growth in shrubs and hardwood trees.

The plant and mine roadways, including the Highway 63 upgrade, will be constructed with culverts and thus should not create water impoundments or flood vegetation.

Soil capability within the Local Study Area is not expected to be altered by the Solv-Ex Development (Section 4.3). There will be some alterations to capability to specific areas for the upgrading of Highway 63 and the loss of productive area resulting from the establishment of an end pit lake. However, the overall capability of the soil will be maintained.

5.6.2.2 Changes in Water Quality

The development of the mine, the construction of the plant and associated structures and air emissions from the co-production processes are not expected to alter the quality of surface water within the Air Resources Cumulative Effects Study Area (Section 5.3).

5.6.2.3 Air Emissions

Vegetation can be affected by air emissions as a result of direct, indirect or secondary effects.

- **Direct** effects may result when plants absorb gases or liquids containing harmful compounds through their leaves. Injury initially takes place at the biochemical level (interference with photosynthesis, respiration, lipid and protein synthesis and reduced plant growth and yield), progresses to the ultra-structural level (disorganization of cellular membrane) and to the cellular level (cell wall, mesophyll and nuclear breakdown) and finally visible symptoms (chlorosis and necrosis of foliar tissue) develop.

- **Indirect** effects are produced when the chemistry or biology of soil or water is changed.

- **Secondary** effects are produced when stress or injury from an air emission predisposes plants to another source of stress or injury such as insects, disease, drought or frost (WHO 1987).

The sensitivities of plant species located in the Local Study Area to SO_2, NO_x and O_3 are listed in Appendix II. Lichens and mosses are considered the most sensitive plant groups to all air emissions because they absorb all their nutrients from the air and rain water (Malhotra and Blauel 1980, Anderson and Treshow 1984). Trees with long life cycles suffer from long-term exposure, because subtle effects can build-up year after year to produce over-all harmful effects (WHO 1987). Deciduous species generally develop symptoms of stress to air emissions more rapidly than evergreens (Malhotra and Blauel 1980, Addison *et al.* 1984). However, evergreens, because of their long foliar retention time, can accumulate contaminants to toxic levels and are more susceptible to lethal injury than deciduous species, which loose their leaves annually (Addison *et al.* 1984).

Sulphur Dioxide

As noted in Sections 5.3.2.2 and 5.5.2.1, waterbodies and soils within the area of influence of SO_2 emissions from the Solv-Ex plant are not at risk of acidification. This is true for the sulphate deposition values from the Solv-Ex plant alone, or when combined with deposition values from the Syncrude and Suncor plants. Therefore, plant species and vegetation communities should not be affected indirectly by SO_2 emissions.

Exposure of plants to relatively high concentrations of SO_2 for a short period of time (i.e., $\leq$24 hours) can cause acute injury, or exposure to relatively low concentrations over a long period of time can cause chronic injury (i.e., >1 day, months or years).

The World Health Organization (WHO 1987) has developed guidelines for the protection of vegetation based on the guidelines prepared by the International Union of Forest Research Organizations (IUFRO) for forests. Two sets of thresholds have been developed: one for areas where forest growth is poor due to environmental stress and the second for areas with more stable and uniform growing conditions. Growing conditions in the Solv-Ex development area are considered to be more stable and uniform. For conditions with more uniform growing conditions, the recommended IUFRO thresholds for SO_2 should be:

- Maximum annual average concentration of 50 $\mu g/m^3$. The ISCON5 model predicts the highest maximum annual concentration from the Solv-Ex operation during normal operation is 7 $\mu g/m^3$ (Section 5.2.2.2).

- The 24-hour average concentration should not exceed 100 $\mu g/m^3$ more than 12 times in 6 months. This means that approximately 93% of the time, the daily average SO_2 concentration should be below 100 $\mu g/m^3$. As shown in Table 5.5 and discussed in

Section 5.2.2.2, on average the facility is expected to be in compliance with the 100 $\mu g/m^3$ guideline.

- 97.5% of the 30-minute average growing season values should be less than 147 $\mu g/m^3$. The 147 $\mu g/m^3$ value is equivalent to 132 $\mu g/m^3$ as a one-hour average concentration. The Solv-Ex plant would produce SO_2 concentrations below this threshold for 96% of the growing season based on the ISCON5 model. The other models predict between 97.1 and 99.6% compliance (Table 5.5, Section 5.2.2.2).

The IUFRO report concludes that these recommended values "are sufficient to protect forest trees".

The WHO recommended guidelines for vegetation in general are:

- Maximum annual average SO_2 concentration (chronic threshold) of 29 $\mu g/m^3$, and
- Maximum 24-hour average SO_2 concentration (acute threshold) of 100 $\mu g/m^3$.

It is noted in the report that these guidelines may not be sufficient in the case of extreme environmental conditions or if other contaminants are present.

Therefore, concentrations of SO_2 produced from the Solv-Ex plant should not exceed the guidelines established by the WHO and IUFRO to protect vegetation from direct effects of concentrations.

Nitrogen Oxide

Nitrogen dioxide concentrations may range up to 95 $\mu g/m^3$ (0.05 ppm) from the Solv-Ex development when natural gas is burned as a fuel (Table 5.8); these concentrations should not negatively influence plants. Physiological functions in plants are not negatively influenced until short-term concentrations reach 2 ppm or greater (Malhotra and Khan 1984). Hanson and Turner (1992) indicate that NO_2 concentrations seldom occur at concentration high enough to induce injury to plants (>0.5 ppm). Studies of plant species native to Alberta indicate that at low concentrations levels, NO_x may be beneficial to plants (Malhotra and Khan 1984).

Ozone

Ozone is potentially damaging emission to vegetation. Ozone is produced in the presence of NO_x and hydrocarbons through photochemical reactions with ultraviolet light (Bohn 1989). WHO (1987) guidelines for the protection of vegetation are 0.1 ppm for 1 hour, 0.033 ppm for 24 hours and 0.03 ppm for the growing season. Lefohn (1992) also presents guidelines based on resistance levels of vegetation to protect vegetation from O_3. For sensitive species the resistance levels are: 0.15 ppm for a duration of 30 minutes, 0.075 ppm for 1 hour, 0.06 ppm for 2 hours and 0.03 ppm for 4 hours. Physiological functions are negatively influenced at concentrations as low as 0.1 ppm (Taylor 1984). Long-term injury appears to occur at 0.04 to 0.08 ppm (Chappelka and Chevone 1992, Taylor 1984). Jack pine and trembling aspen are considered sensitive to O_3 (Chappelka and Chevone in: Lefohn 1992).

Potential effects of ozone on vegetation are difficult to assess, but NO_x emissions from the Solv-Ex project are low and thus ozone transformation levels and impacts to vegetation should be low.

Interactive Effects of SO_2, NO_x and O_3

Plant responses to emissions in combination depend on the components of the mixtures, the concentrations of each component and their temporal sequence (Torn *et al.* 1987). The interactive effect of SO_2 concentrations in combination with other contaminants on plants can be described three ways:

- The plant response to emission mixtures is additive and is similar to the summed effects of the individual compounds,
- The plant response is antagonistic (less than additive), or
- The plant response is synergistic (greater than the additive).

Synergistic, additive and antagonistic interactions that result in decreases in plant growth and yield have been observed for exposures to mixtures of SO_2 and O_3, SO_2 and NO_2, and SO_2, O_3 and NO_x.

The interactive effects of SO_2 and NO_x from the Solv-Ex, Suncor and Syncrude projects, with naturally occurring O_3, on vegetation are difficult to predict due to the high variability of responses amongst plant species and to various concentrations.

5.6.3 *Reclamation*

Reclamation of the mine area will begin in 1998 and will be phased during the operating period. At the completion of mining, the 30 ha end-pit will be allowed to fill with water to create a lake. The remaining mine area of 20 ha will be revegetated to coniferous, deciduous and mixedwood forests (Table 5.19). This will return 60% of the current forest capability to the mine area.

At the completion of the Solv-Ex project, reclamation of the remaining development area (minus the mine site and Highway 63) will return 267 ha of land to productive forest. The forest communities replaced will include aspen (124 ha), mixedwood forest (121 ha) and coniferous forests of white spruce, jack pine and black spruce (22 ha) (Table 5.19). This will increase productive forest land for the total area (including the mine site) by approximately 400%.

A mosaic of vegetation communities, similar to that found prior to disturbance will be recreated. This will include the restoration of the shrub and herbaceous species contained within the white spruce, aspen and jack pine series of vegetation communities. This is intended to restore some of the ecosystem elements to the reclaimed area.

Table 5.19 Forest vegetation communities to be re-established within the Solv-Ex Development Area.

Forest Community	**Lease 5 Development Area (minus the mine site) (ha)**	**Mine Site (ha)**	**Total**	**% of Area**
Coniferous Types	22	15	37	11
Deciduous Types	124	3	127	39
Mixedwood Types	121	2	123	37
End-pit Lake	-	30	30	9
Highway 63	14	-	14	4
TOTAL	281	50	331	100

5.6.4 *Summary of Residual Impacts*

The residual impacts of the Solv-Ex Experimental Co-production project on vegetation communities during the Life of the Project and Post-Operation are summarized below.

Forest fire suppression activities will be undertaken during the development of the Solv-Ex project. Vegetation will be cleared to provide sufficient distance to limit the potential of fire escape from the Solv-Ex facilities and will provide a barrier to wildfire.

SO_2 and NO_x concentrations resulting from the Solv-Ex project are not predicted to have direct or indirect (e.g., through water or soils) effects on vegetation. Predicted concentrations are within the WHO and IUFRO guidelines specified to maintain forest vegetation health.

However, the interactive effects of O_3, alone, or SO_2, NO_x and O_3 on plant growth and yields are difficult to predict due to the variability of responses amongst plant species and to various concentrations (Undetermined Impact).

There will be no minor changes to vegetation due to changes in drainage patterns as a result of the development of the Solv-Ex project.

Life of Operation:

- There will be a loss of 331 ha (7%) of the vegetation communities within the Local Study Area as a result of site clearing. This will include black spruce (57%), fen (11%), aspen, (9%) and aspen/jack pine (8%) community types. This Moderate magnitude, Negative impact will be Local in spatial extent, Phased and Irreversible over the 7 year life of this project (Moderate duration).

Post-Operation:

- The 331 ha (7%) of the plant communities, within the Local Study Area, lost as a result of site clearing will partially be replaced following reclamation. A portion of the mine will be reclaimed to a 30 ha end-pit lake and 14 ha will be permanently removed due to paving of Highway 63. The remaining 287 ha will be reclaimed to vegetation communities; aspen (127 ha), mixedwood forest (123 ha) and coniferous forests of white spruce, jack pine and black spruce (37 ha). This will increase specific resource values such as aesthetics, timber productivity (400%) or wildlife, but will not completely return the site to the pre-construction species composition or community structure. The impacts will be Positive, Long-term in duration, Local in spatial extent, Moderate in magnitude, Phased and Irreversible, as the capability of the site and the plant species composition will be altered.

5.6.5 *Vegetation Monitoring*

A monitoring program will be designed to document the re-establishment of plant species and community types on reclaimed sites. Plots will be established to examine plant species composition.

5.7 Wildlife Resources

Three groups of terrestrial wildlife species were selected to assess impacts to wildlife from the Solv-Ex project: **ungulates** (i.e., moose and deer), **furbearers** (i.e., snowshoe hare, red squirrel, coyote, fox, wolf, marten fisher, weasel, lynx and wolverine) and **terrestrial birds** (i.e., passerine and upland game birds). These species groups were selected because of their economic, recreational and ecological importance, and they are representative indicators for impact assessment. Groups not discussed in the assessment are aquatic wildlife (i.e., waterfowl, aquatic furbearers, reptiles and amphibians) and raptors. This reflects the fact that the proposed Solv-Ex Development Area supports very little, and only low capability aquatic habitat for wildlife. Fort Creek, which is located in the vicinity of the proposed Development Area will not be impacted. Although the Athabasca River is an important migration corridor, the project effects on water quality or flows will be negligible (Section 5.3). Raptors were not considered because typically their home range sizes are large compared to the size of the Local Study Area.

Potential effects of the Solv-Ex project on wildlife that are considered negligible, and are not discussed further include:

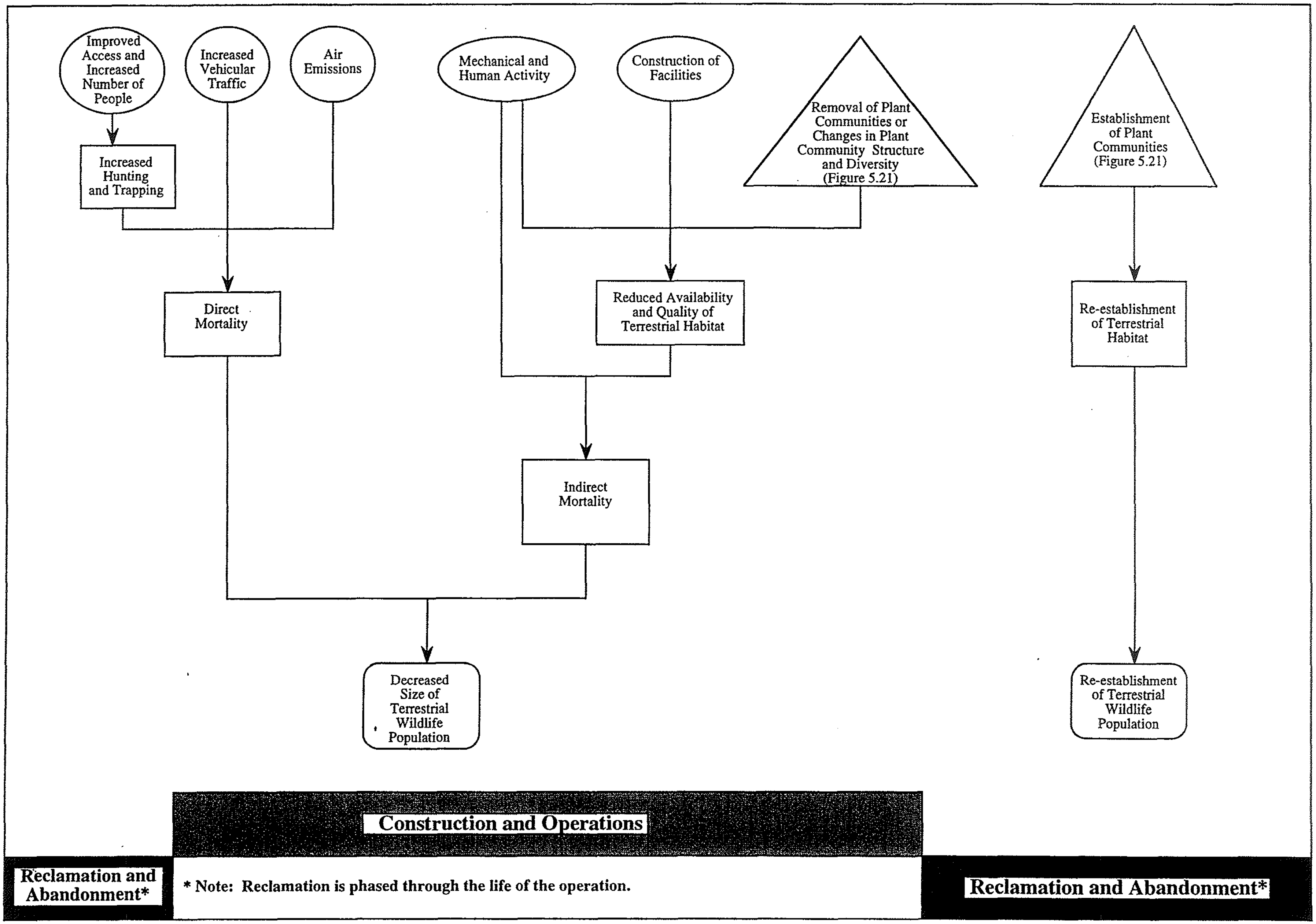
- Removal of nuisance black bears. A bear management program will be implemented at the landfill, if one is eventually constructed. Garbage will be incinerated and buried, and the disposal site fenced. Removal of problem wildlife should be minimal, and will be resolved with direction from Alberta Fish and Wildlife.

- Removal of problem beaver. Except for Fort Creek, there is limited habitat for beaver in the vicinity of the Development Area. Some removal of beaver that block culverts and cause backflooding is expected, and will be completed under the direction of Alberta Fish and Wildlife.

5.7.1 *Direct Mortality to Wildlife*

Activities associated with the Solv-Ex project that will affect wildlife resources can be divided into those causing direct mortality, and those causing indirect mortality due to habitat change or alienation (Figure 5.22). Direct mortality could result from increased traffic levels, increased hunting and trapping due to improved access and increased number of people in the area, and direct effects of air emissions. Indirect mortality could result from habitat loss through site clearing and habitat alienation, and habitat fragmentation.

Figure 5.22 **Construction of facilities, the removal of plant communities and changes in plant community structure and diversity, during the construction and operations phase and the establishment of plant communities during the reclamation and abandonment phase will change the availability and quality of terrestrial habitat. Improved access, increased number of people, increased vehicular traffic, air emissions, mechanical and human activity, and changes in the availability and quality of terrestrial habitat will *change the size of terrestrial wildlife populations.***



5.7.1.1 Increased Hunting and Trapping due to Improved Access

Until the past two decades, access to the LSA and BCESA has been almost exclusively by boat (Fort McKay Environmental Services 1995; Appendix VIII). Currently access to the Lease 5 area occurs via a winter road, a summer trail and the Athabasca River. Access will be improved, over all seasons, with the upgrading of Highway 63. During the construction and operation phase, improved access will be limited to areas south of Lease 5, but after reclamation and project abandonment, access within the Development Area will also improve. This improved access and the increase in the number of people in the area (particularly during the construction and operations phase), could increase hunting pressure on game species of wildlife. Improved access due to development of the oil sands projects between Fort McMurray to areas north of Fort McKay in the mid-to-late 1970's, contributed to increased harvest of ungulates, particularly moose, as a result of licensed sports hunting (fall), subsistence hunting (year-round) and poaching (Hauge and Keith 1980, Westworth 1979*b*, Fort McKay Environmental Services 1995; Appendix VIII).

Improved access should not increase trapping pressure on furbearers. All the area to which access will be improved is currently allocated for trapping under Registered Trapping Areas 1650 and 2137. Therefore trapping pressure should not increase beyond current levels and may be dictated more by fur prices than by access. There are no trapping quota limits in the region for hare or squirrel, although trapping of wolverine, fisher, lynx and otter is restricted (F. Neuman, Fur Management Coordinator, Alberta Fish and Wildlife, pers. comm.).

In summary, trapping pressures are not anticipated to increase due to improved access, however, hunting pressures may increase, and thus hunted species such as moose, hare and spruce grouse may experience increased mortality.

5.7.1.2 Increased Vehicular Traffic

During the construction and operations phase of the Solv-Ex project, there will be an increase in the volumes of traffic using Highway 63. This increase in traffic and in vehicle speeds on the upgraded portion of Highway 63, will increase the potential for wildlife-vehicle collisions.

Vehicle collisions can be attributed to two sets of factors: those related to the vehicles (number and speed) and roads (number, type of construction and maintenance), and those related to wildlife populations (species, density and structure of population, behavior and environmental factors). Some general statements on wildlife collisions are:

- Despite the high mortality experienced by some wildlife species as a result of road kills, the loss for most species is not significant because of the small proportions of ranges of most species being affected by the roads and due to the compensatory mortality experienced by some species.

- Sopuck *et al.* (1979) indicates that problems with vehicle-wildlife collisions are severe immediately after construction of roads, or following increases in traffic volumes.

- Wildlife mortality is greatest in late fall in association with migration, rutting and hunting (review *in* Sanderson 1983) and during breeding seasons (Allen and McCullough 1976) and dispersal of young (Bellis and Graves 1971: Oxley *et al.* 1974). Road kills peak during 0600 to 0800 hours, and between 1800 and 2400 hours (Allen and McCullough 1976; Bellis and Graves 1971; Damas and Smith 1982; Flygare 1979), when the driver's field of view is reduced and when many wildlife species are most active.

Traffic associated with the Solv-Ex project has been projected to be 200 vehicles during the construction phase and 230 vehicles during the operations phase (Table 5.20). These numbers would add insignificantly to existing traffic volumes on Highway 63, up to the location of the Syncrude Plant (Table 5.20), but would at least double or triple existing traffic volumes from the Syncrude plant turn-off to the proposed Solv-Ex Development Area. Future projections of traffic volumes from other developments are also provided in Table 5.20.

From 1989 through 1993, there were no reported wildlife-vehicle collisions on the highway between the Syncrude plant and the crossing of the Athabasca River crossing (Alberta Transportation and Utilities, Brian MacKenzie, Traffic Analyst, pers. comm.). On the highway from Fort McMurray to the Syncrude plant turn-off, there was an average of 3.6 collisions per year, which produced greater than $1,000 damage to vehicles. A list of all species recorded for wildlife-vehicle collisions is shown in Table 5.21.

Based on increased traffic volumes related to the Solv-Ex project (Table 5.20), a slight increase in wildlife-vehicle collisions may occur. If the relationship between traffic volumes and wildlife-vehicle collisions is assumed to be linear, the increase in wildlife-vehicle collisions due to project-related traffic on the highway from Fort McMurray to the Syncrude plant turn-off would increase an average of 0.2 collisions/year. Vehicle collisions would likely increase on the highway beyond the Syncrude plant, but quantifying this increase is not possible.

5.7.1.3 Direct Effects of Air Emissions

Species-specific information on the direct acute (short-term) and chronic (long-term) effects of SO_2 and NO_x concentrations on wildlife, especially under natural conditions is lacking (Schreiber and Newman 1990). The direct response of wildlife to SO_2 can be highly variable depending on the species and age of the animal affected, and the concentration of the emission and duration and frequency of exposure.

- The highest SO_2 concentrations associated with the Solv-Ex project will occur during flaring. Based on modelling results, ambient concentrations will not exceed 450 $\mu g/m^3$ (0.17 ppm) (Section 5.2.2). During normal operations and using diesel fuel, hourly average SO_2 concentrations may range up to a maximum of 419 $\mu g/m^3$ (0.16 ppm) (Table 5.3). During abnormal worst-case conditions using diesel fuel, hourly SO_2 concentrations off-site could range up to 475 $\mu g/m^3$ (0.18 ppm) (Section 5.2.2). SO_2 is classified as a mild respiratory irritant, that can cause increase inflammatory changes in tissue of the respiratory tract, decreased mucous activity and less effective respiratory

Table 5.20 Changes in traffic flow on Highway 63 between Fort McMurray and the Solv-Ex Development Area during construction and operation phases. Numbers in parentheses are percentages of average 1992/1993 traffic levels.

Portion of Highway	Average 1992/1993 Traffic Levels (Average Annual Daily Traffic)[a]	Future Projection of Traffic Associated with Al-Pac and the Susan Gravel Pit[b]	Solv-Ex Projected Traffic Increase	
			Construction[c]	Operations[d]
Fort McMurray to Suncor Turnoff	3485	60	200 (6)	234 (7)
North of Syncrude Turnoff	2810	60	200 (7)	234 (8)
South of Fort McKay Turnoff	185	60	200 (108)	234 (127)
North of Fort McKay Turnoff	80	60	200 (250)	234 (293)

[a] Source: Alberta Transportation and Utilities. 1995. Technical Services Planning Branch, Edmonton.

[b] Based on an estimated 40 truckloads of wood per day for Al-Pac during peak harvest periods during the winter months and 20 truck loads of gravel from the Susan Gravel Pit, all one way per day.

[c] Based on 200 cars one way per day.

[d] Based on 110 PCO trucks, 20 mineral trucks, 4 employee buses and 100 private vehicles, all one way per day.

Table 5.21 Summary of mortalities due to reported wildlife-vehicle long Highway 63 north of Fort McMurray to the Solv-Ex Development Area.

Species	Year[a]								
	1985-6	1986-7	1987-8	1988-9	1989-90	1991	1992	1993	1994
Moose	0	0	3		2	0	0	0	1
Deer	1	3	2	3	0	3	0	5	1
Fox	0	0	0	0	2	0	0	1	0
Wolf	1	0	0	0	0	0	1	0	0
Black Bear	0	1	2	0	0	1	0	2	3
Coyote	0	0	1	0	1	0	1	0	0
Great Horned Owl	0	0	0	1	1	0	1	0	0
Merlin	0	0	0	0	1	0	0	0	0
TOTAL	2	4	8	4	7	4	3	8	5

[a] Source: Alberta Transportation and Utilities.

pathway clearing, and increased airway resistance (Prior *et al.* 1982). Wildlife species exposed to low concentrations of SO_2 (0.01 to 5 ppm) may experience eye or respiratory tract irritations, small changes in breathing patterns and rhythms, or behavioural changes (review in Jim Lore & Associates 1989).

High concentrations of SO_2 can result in bronchoconstriction and chemical bronchitis and tracheitis (World Health Organization 1987, Prior *et al.* 1982). Exposure to SO_2 concentrations > 400 ppm can cause mortality within 24 hours in most animal species (Aviado and Salem 1968, Battigeli 1969), to 1000 ppm can cause mortality within 4 hours and to 3000 ppm can cause mortality within 1 hour.

- NO_2 concentrations may range up to 95 $\mu g/m^3$ (0.05 ppm) from the Solv-Ex development when natural gas is burned as a fuel (Table 5.8). Although the effects of NO_2 on free-ranging animals are not well known, the predicted concentrations are lower than those documented to have physiological effects on animals. For example, NO_2 can trigger biochemical changes at concentrations of 0.2 ppm with 30 minute exposures (World Health Organization 1987); rats, mice, rabbits and guinea pigs exposed to concentrations of 0.1 to 0.5 ppm of NO_2 for several hours showed kidney damage, liver disfunction, interference with hormone metabolism and generalized lung damage (Goldstein 1984 *in* Western Research 1989); and higher levels of NO_x can influence the pulmonary and central nervous systems of birds and mammals (Newman 1980).

- Newman and Schreiber (1988), Peterson (1982) and Shaw (1983) note that, due to the irritant nature of the emission, wildlife will leave or avoid an area being fumigated by SO_2 emissions. A two year study of moose in the vicinity of SO_2 producing gas plants showed that the density, productivity and habitat utilization of this ungulate was not correlated with distance from the sour gas plant (Wride 1975). It is likely wildlife will respond similarly to NO_x.

In summary, concentrations of SO_2 and NO_x emitted by the Solv-Ex plant should have no effects on wildlife, beyond occasional transient health effects.

5.7.2 *Indirect Mortality to Wildlife*

Habitat alteration (changes in food or cover) as a consequence of the Solv-Ex Project will change the carrying capacity of the area for terrestrial wildlife. The removal of habitat through clearing or displacement, modifications of plant community structure and diversity (that reduce the availability of food or cover), and the blockage of portions of wildlife range from use will reduce carrying capacity. Alternately, the re-establishment of vegetation through reclamation (Section 5.7.3) will increase carrying capacity.

5.7.2.1 Habitat Alterations

Vegetation Clearing and Habitat Avoidance

Vegetation clearing for the project facilities will result in the loss of about 331 ha of habitat in the Local Study Area, 296 ha in Lease 5 and 35 ha within the Utility Corridor (Table 5.22). The dominant habitats to be lost will be open black spruce (58% of habitat removed), followed by shrub (13%), aspen (9%) and closed black spruce (8%). Habitat will be removed for the Life of the Operation (7 years) and for the time necessary for various habitat types to regenerate (1 to 80 years). The clearing and reclamation of the mine site will be phased, therefore, animals will be displaced in a step-wise manner over the life of mine development. This approach will minimize the area of habitat disturbed at any point in time.

- Based on regional studies, aspen forest, mixedwood forests and shrublands, which account for about 30% of the vegetation types being cleared for development (Table 5.23), provide important habitat for moose (Section 4.7.2.3). Although the lowland habitats, which account for over 65% of the area being cleared, are seldom used by moose, the open lowlands provide the first high quality food in spring. The salt lick identified by the Fort McKay Environmental Services 1995 (Appendix VIII) should not be affected by development (Figure 4.27).

- As noted in Section 4.7.2.3, the most common furbearers and carnivores in the vicinity of the LSA and their habitat preferences are: snowshoe hare (prefers aspen and spruce dominated forest), followed by red squirrel (coniferous-dominated forest particularly white spruce), and then fisher (dense coniferous and mixed forests) and weasel (all habitats). Habitat use by carnivorous furbearers is dependent on the location of their prey species. White spruce stands and habitats with shrub cover would provide good quality habitat for many prey species such as hare, red squirrel and microtine rodents. Therefore, some good quality habitat will be lost to furbearers through site clearing.

- Over 60% of the habitat being cleared, particularly black spruce muskeg, provides good habitat for spruce grouse, while about 20% of the habitat being cleared, particularly deciduous and mixedwood forests, provides good habitat for ruffed grouse (Table 5.23).

- The densities of terrestrial birds, based on breeding bird plots in the vicinity of the Bitumount Historic Site, ranged from 91 to 583 territories per 100 ha (Francis and Lumbis 1980). Densities varied with habitat type, with jack pine habitats supporting the lowest densities and numbers of species, and mixedwood and shrub habitats supporting the highest densities and numbers of species. The large variability in number of birds between years was attributed to fluctuations in the use of sub-optimal habitats during years with high breeding bird populations. With the clearing of 331 ha of habitat, dominated by black spruce, aspen and deciduous dominated mixedwood forests, about 1500 pairs of passerines could be displaced.

Table 5.22 Habitat loss due to clearing and avoidance in Lease 5 and along the utility corridor.

	Habitat Cleared	**Habitat Avoidance**	**Total**
Lease 5	296 ha	927 ha	1223 ha
Utility Corridor	35 ha	N/A	35 ha

Table 5.23 Habitat disturbed by clearing and habitat avoidance due to mechanical and human activity within Lease 5.

Habitat Lease 5	**Habitat Cleared (ha)**	**Percent of Total (%)**	**500 m Habitat Avoidance Area (ha)**	**Percent of Total (%)**
White spruce	3	1.0	11	1.2
Jack pine	< 1	0.1	6	0.7
Open black spruce	173	58.5	396	42.7
Closed black spruce	24	8.1	37	4.0
Mixed coniferous	0	0.0	46	5.0
Aspen	26	8.8	162	17.5
Deciduous dominated mixedwood	28	9.4	130	14.0
Coniferous dominated mixedwood	4	1.2	15	1.6
Shrub	38	12.9	55	6.0
Sedge meadow	0	0.0	0	0.0
Disturbed	0	0.0	68	7.3
Wetlands	0	0.0	0	0.0
TOTAL	296	100.0	927	100.0

Some species of wildlife will avoid using habitat adjacent to developments, due to disturbance from human and mechanical activities. For the purposes of this study, it has been assumed that wildlife will be displaced from habitat within 500 m of facilities located in Lease 5, or from 927 ha of habitat (Table 5.22). This is a worst-case estimate as it is known that some species habituate and are not displaced 500 m. Noise levels from the plant will be within the guidelines of the ERCB Noise Control Directive i.e., 40 dBA Leq (ERCB ID 94-4) within a 1.5 km radius from the proposed plant site (Section 2.2.3.8).

- Continuous sensory disturbance may result in passive avoidance of suitable habitat by ungulates (Geist 1975, 1978; Sopuck *et al.* 1979). Although avoidance behavior has not been well documented in moose, some research indicates that this species shows low use of clearcut areas due to human disturbance (Stelfox *et al.* 1976), is displaced from roadways (Rolley and Keith 1980) and avoids active seismic lines by 1 km (Horejsi 1979). It is known, however, that moose can habituate to continuous noise (Beak 1979, Shank 1979, Tracy 1977). Negative effects of disturbance on the reproductive activities of ungulates include: disruption of reproductive activities (e.g., calving, rut) and/or failure to breed, malformation or death of fetus, and trampling and abandonment of young (Geist 1975, Hoffos 1982).

- Depending on the species, furbearers could be affected very little, or to a greater degree by disturbance. Fisher, marten and lynx are very sensitive to disturbance; therefore, the 500 m displacement distance is reasonable. Hare will avoid habitat within 100 to 200 m of disturbances such as snowmobile trails and highways. Canids such as the coyote can habituate to disturbance. Fort McKay Environmental Services (1995; Appendix V) note that the number and species composition of furbearers in Registered Trapping Areas (within the Local Study Area) have decreased over the past 10 years due to increasing disturbance and noise in the area, and that the Solv-Ex project will further displace species such as fisher.

- Most species of upland game birds and passerines show little habitat avoidance in areas where the vegetation has not been disturbed.

Fort McKay Environmental Services (1995; Appendix V) also state that the increase in number of humans and the increased pressure on both habitat and the animals themselves, will undoubtedly result in a general reduction of numbers unless specific actions are taken to provide both habitat and security for these animals while they adapt to the new environmental regime.

There have been losses of habitat within both the Local Study Area (LSA) and the Biophysical Cumulative Effects Study Area (BCESA) due to previous developments. Within the LSA, about 411 ha or 10% of habitat have been previous cleared (Table 5.17); therefore, the development of the Solv-Ex project will increase habitat disturbed to a total of 742 ha or 17% of the LSA. Within the BCESA, about 2385 ha of habitat or 4% of the area have been previously cleared; therefore, the Solv-Ex project will increase habitat disturbed to a total of 2716 ha, or 5% of the BCESA.

Barriers to Movement

Structures constructed along the Athabasca River and the removal of large blocks of habitat could restrict the movement of ungulates and isolate animals from portions of their home range.

Moose and other species such as wolf and bear may use the Athabasca River as a movement corridor, however, the extent of it's use by wildlife has not been documented. Movement corridors can be relatively broad and consist of several travel lanes. Movement may reflect daily activity by resident animals, or activity by migrants that seasonally move into the project area in early- to mid-winter.

Movement of wildlife along the Athabasca River may be disrupted during the early years of development of the mine. To minimize negative effects, constructing a berm/vegetation screen along the west edge of the mine would reduce noise and visual disturbance to wildlife moving through habitats adjacent to the river.

Indirect Effects of Air Emissions

Although terrestrial wildlife can be affected by air emissions directly (inhalation and adsorption), most effects are indirect (ingestion of contaminated food, loss of food resources or production in nutritional value, or habitat degradation; Borghi 1982, Schreiber and Newman 1990). Reduced vigor or loss of plant species and a simplification of plant community structures could reduce the number or change the type of niches available to wildlife.

Maximum average annual concentrations of SO_2 and NO_x from the Solv-Ex are too low to directly affect vegetation (Section 5.6) and sulphate deposition was assessed to be too low to acidity soils or water (Sections 5.3.2.2 and 5.5.2.1). Therefore, emissions from the Solv-Ex plant should not alter the structure of plant communities or the capability of habitats to support various wildlife species.

5.7.3 *Re-establishment of Habitat*

Construction and Operations Phase: During the construction and operations phase there will be limited increase in habitat available for wildlife. Browse species, such as willow, aspen, balsam poplar and birch, may increase in abundance in the vicinity of the mine, roadways and interceptor ditches where drainage will be improved, and benefit wildlife species that depend on browse i.e., moose.

Reclamation Phase: Solv-Ex will pursue a "no net loss" of habitat policy. Because the establishment of mid- to late-successional habitat takes many years after a site has been reclaimed, wildlife communities following oil sand mining will be inherently different from the communities occurring on the site preceding development. Lease 5 will be reclaimed to a mosaic of landforms and three habitat types: aspen forest (127 ha), mixedwood (123 ha) and shrub within open black spruce forest (37 ha) habitats. Reclamation of the mine will be phased, so that habitats will be re-established as soon after disturbance as possible. The time periods required to re-establish plant communities will be: 1 to 3 years for shrub habitat, 15 to 45 years for aspen, 40 to 60 years for mixedwood forest and 80 to 100 years for coniferous (Section 5.9.2.2). Part of the mine will be reclaimed as a 30 ha end-pit lake that could support aquatic wildlife such as waterfowl and beaver. The 21 ha of disturbed land within the Utility Corridor will be reclaimed to grass and shrubland, reflecting the habitat types that currently exist along the right-of-way (14 ha will be permanently lost due to upgrading of Highway 63).

Aspen, mixedwood and shrub habitats on the reclaimed site should provide equivalent habitat value for moose than existed prior to development. The clearing of the site and creation of early successional habitat may provide good habitat for deer and increase their numbers (For McKay Environmental Services 1995; Appendix V). Snowshoe hare which can utilize early seral stages of vegetation such as aspen and shrub habitats will show positive increases. Species such as lynx, fisher, fox and coyote whose use of habitat is dependent on prey species will benefit from increased populations of snowshoe hare and microtine rodents on reclaimed areas. Species requiring older forest habitat such as red squirrel and marten will not benefit until stands are established by natural successional changes (up to 80 years). Shrub habitat had one of the highest numbers of terrestrial breeding birds in Francis and Lumbis (1980) breeding bird inventory. Therefore, reclaiming a portion of the site to shrubland will have a positive effect on terrestrial passerines.

Other forms of habitat enhancement (e.g., sharp-tail grouse artificial dancing grounds; Fort McKay Environmental Services 1995) could be considered during reclamation.

5.7.4 *Summary of Residual Impacts*

The residual impacts of the Solv-Ex project on wildlife during the Life of the Operation and Post-Operations are described below.

SO_2 and NO_x emissions from the Solv-Ex plant are too low to impact wildlife either directly through inhalation or adsorption, or indirectly through reductions in the quantity or quality of food and cover, or the ingestion of contaminated food or water.

The loss of wildlife due to the removal of nuisance species is not expected to decrease wildlife populations, although the occasional animal may be removed by Alberta Fish and Wildlife.

It is difficult to assess what portion of the moose or canid populations that use the Athabasca River as a movement corridor may be affected by barriers to movement created by development of the mine and other facilities. The construction of a vegetated berm along the west edge of the mine may mitigate this effect (Undetermined Impact).

Life of Operation:

- Within Lease 5, a total of 296 ha of habitat will be lost due to vegetation clearing and up to 927 ha due to habitat avoidance (worst case scenario). Within the Utility Corridor a total of 35 ha of habitat will be lost due to clearing, but there will be no increase in habitat loss due to alienation. Habitat loss is considered to be an impact Moderate to High in magnitude, Negative, Long-term in duration, Continuous (due to the phased nature of vegetation clearing and disturbance), Local to Regional in scope, and Irreversible during the Life of the Project.

- There will be an increase in wildlife mortality due to wildlife-vehicle collisions as a result of increased traffic levels from the Solv-Ex project, on Highway 63. This impact is considered to be Low in magnitude, Negative, Moderate-term in duration, Continuous through the Life of the Project, Regional in Scope and Reversible if mortality rates remain low.

Post-Operation:

- Over time site reclamation will replace the quality and capabilities of habitat that will be lost due to clearing of the Development Area. However, reclaimed habitat will not provide capability equivalent to pre-disturbance levels for several years after the end of project operation. After a few years, the successional vegetation will provide high quality habitat for species such as moose, bear and hare that depend on early to mid-successional habitat. This impact is considered Moderate in magnitude (7% of LSA), Positive, Long-term in duration, and Local to Regional in scope (other impact terms not applicable).

- There may be a decrease in the populations of hunted wildlife species (e.g., moose, upland game birds) due to increased hunting pressures as a consequence of improved access along the upgraded Highway 63 and within the Development Area. This impact is expected to be Low to Moderate in magnitude, Negative, Local to Regional in scope and Long-term in duration (other impact terms not applicable).

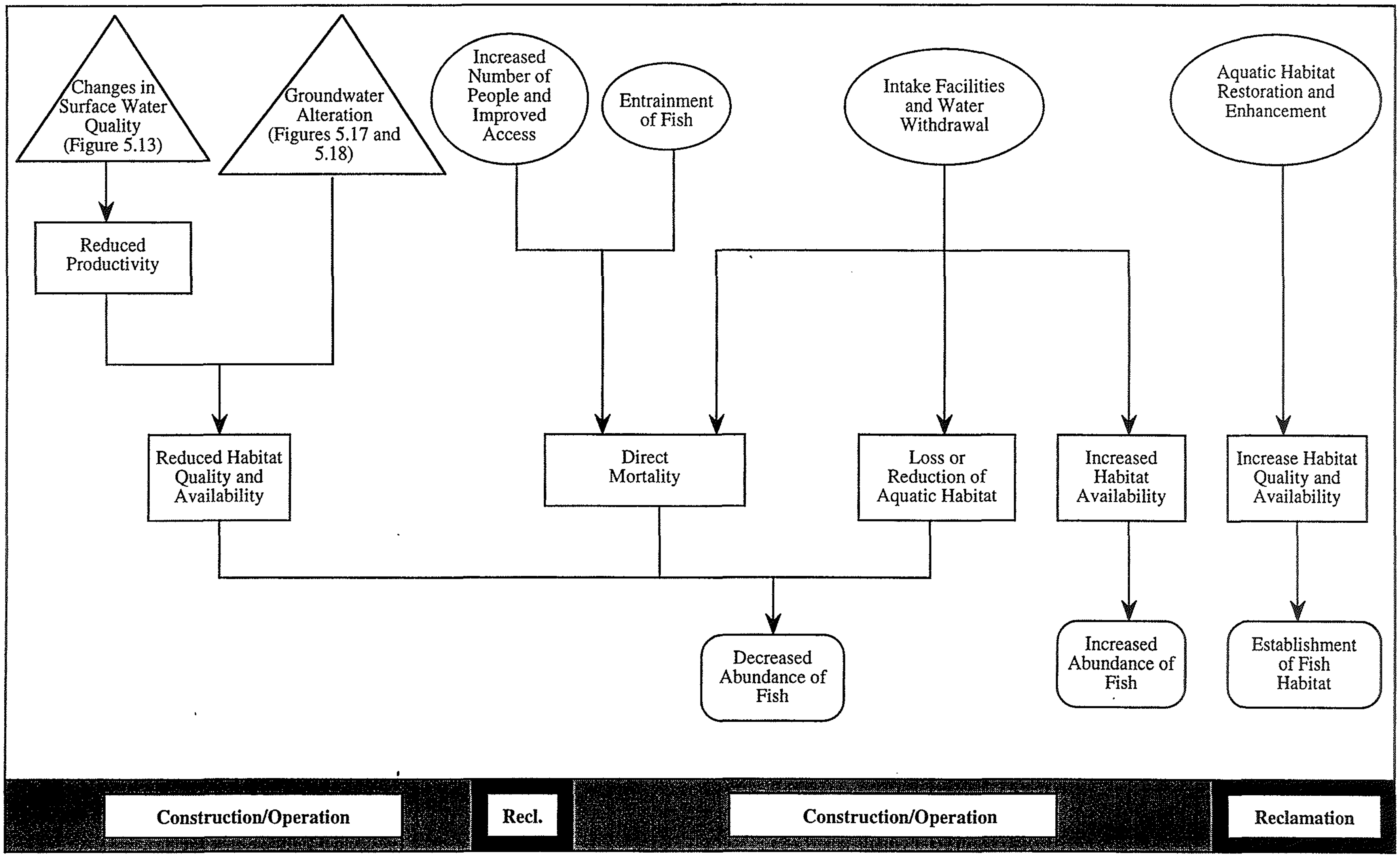
5.7.5 *Wildlife Monitoring*

Monitoring programs established to examine the composition and structure of vegetation types on reclaimed sites will be used to evaluate the quality and value of habitat for wildlife species. No monitoring programs to assess changes in wildlife population levels are recommended.

5.8 Fish and Aquatic Resources

Activities associated with the Solv-Ex Project that could impact aquatic habitat and associated fish and other aquatic resources, include changes in local water quality and flows, and direct mortality through entrainment during withdrawal of water from the Athabasca River and increased fishing pressures (Figure 5.23).

Figure 5.23 **Surface water quality changes, water diversions and intake facilities, groundwater alterations, improved access, increased number of people, aquatic habitat restoration, and reclamation will *change the quality and availability of aquatic habitat and fish abundance.***



5.8.1 *Decreased Abundance of Fish*

Solv-Ex plans to avoid Fort Creek in all of its operations, therefore no direct loss or alteration of aquatic habitat due to construction or operational activities is anticipated. Based on comparison to other small streams in the region, Fort Creek is expected to currently display severe limitations for fish production.

Changes in Surface Water Quality: Changes may occur in local surface water quality in the Athabasca River, primarily as a result of increases in suspended sediment and organic materials. These changes in water quality could have a negative impact on primary and secondary productivity by:

- Smothering of aquatic plants, periphyton and benthic invertebrates (resulting in loss of food for fish), changes in the bottom substrate and degradation of habitat for bottom feeders (further loss of food for higher organisms), and increased abrasion of biota affecting body organs such as gill structures in both aquatic insects and fish and interfering with filter feeding of invertebrates (Hynes 1973, Rosenberg and Snow 1975).

- Increasing turbidity and thus decreasing photosynthesis in phytoplankton, algae and rooted plants by reducing light penetration (Abel 1989, McNeely *et al.* 1979).

Extreme sedimentation and high turbidity levels can also directly affect fish populations by deposition on spawning areas (smothering the eggs or alevins), and affecting feeding success (Hynes 1973, EIFAC 1965).

In the Solv-Ex Project area, the potential impact on aquatic communities will parallel the degree of change in sediment loads and runoff entering the Athabasca River from the project area and associated roads. Within the Solv-Ex Project area, erosion and sediment transport will be controlled by a number of techniques and in most cases impacts will only be short-term until the structures are in place or revegetation occurs. All surface waters from the plant site and disturbed areas of the mine will be collected and diverted to settling ponds before being released to the Athabasca River. In addition, the Athabasca River is relatively turbid with high suspended sediment levels during much of the open water season (McCart *et al.* 1977) and impacts on biota in the Athabasca River from local additions of sediment are likely to be low in magnitude or negligible (Section 5.3.2).

Potential impacts on fish populations could occur from discharge of wastewater to the river. However, all water discharged to the river will meet Alberta Environmental Protection Surface Water Quality Objectives prior to release, and thus should have negligible effects on fish.

Groundwater Alterations: The release of basal groundwater from the mine could affect water quality if it enters watercourses. High concentrations of mine depressurization groundwater can be toxic to benthic invertebrates and fish (Tsui *et al.* 1980), but, toxicity is reduced with dilution and is negligible at a dilution of 5 to 1. No evidence of toxicity was noted on Syncrude Canada oil sands operations (Jantzie *et al.* 1980). Any saline water encountered in the Solv-Ex mine will be routed to a settling pond prior to (after meeting Alberta Environmental Protection standards) release into the Athabasca River. No direct effects on productivity or fish are therefore expected.

Improved Access: Improvements to access along the Athabasca River, other regional waterbodies of the east of the project area, and reclamation sites will likely occur as a result of the upgrade of Highway 63. Improved access would continue after project abandonment. The project will also result in additional temporary and permanent workers. Where sportfish occur (e.g., walleye, northern pike and Arctic grayling), these populations will be subjected to increased fishing pressure and may require additional fisheries management/ enforcement.

Water Withdrawal and Fish Entrainment: Approximately 5.0 Mm^3/a of water will be withdrawn from the Athabasca River during start-up, and 2.5 Mm^3/a during average operations. These volumes represent a minor decreases in Athabasca River flows of 0.2% and 0.1% of minimum recorded January flows, respectively (Section 5.3.1). The cumulative effect of water withdrawal by Syncrude, Suncor and Solv-Ex on flow in the Athabasca River during January, the lowest historic flow month, is a reduction of less than 2% of the flow (Section 5.3.1). These flow reductions will not negatively affect fish or other aquatic resources.

Water intake facilities at the Solv-Ex Project will result in entrainment of fish (generally eggs, drifting fry, and other small fish) with undetermined losses (direct mortality) as a result of impingement on screens or mechanical damage from the pumping. Entrainment will be dependent on the final design characteristics of the intake and will vary seasonably (e.g., fish species, life stage). Screening (as required by Section 30 of the Fisheries Act, Canada) will likely be required at the water intake and will prevent entrainment of a majority of fish. Directives and guidelines for screening have been provided by both Federal and Provincial agencies; applicable design criteria for Alberta are summarized in the Fisheries Habitat Protection Guidelines, Guideline No. 10 (Alberta Environmental Protection 1993).

Habitat alteration will occur primarily on the Athabasca River in the vicinity of the water intake facility. Bank habitats along the stretch of the Athabasca River adjacent to Lease 5 are primarily erosional with bank habitat diversity being amongst the lowest recorded during fisheries surveys of the mainstem river in spring 1992 (R.L. & L. 1993). Fish abundance associated with this habitat type was low (R.L. & L. 1993); consequently potential impacts or losses of fish habitat and fish production will be low, although duration will be long-term (Life of the Project). Bank stabilization or protection from erosion associated with the intake facility will increase habitat diversity and cover types for fish in the local area. Nearshore fish habitat diversity and cover could be further enhanced through additional bank protection (e.g., large rip-rap) in the minesite and water intake areas.

5.8.2 *Increased Abundance of Fish*

If the Solv-Ex Project does not evolve to the commercial phase, establishment of an end-pit lake in the reclaimed mine will create approximately 30 ha of new aquatic habitat. Details on water chemistry and morphometry are unavailable, but the lake will not likely have inlet or outlet streams and thus will be inaccessible to fish from the Athabasca River. However, suitable habitat may still be available from non-resident stocked fish (e.g., a rainbow trout put-and-take fishery) and some native minnow and coarsefish species could be expected to survive if introduced via pumped or make-up water.

Fish habitat enhancement may also be possible off-site, within the region. Local areas, such as the confluence and lowermost reach of Fort Creek, could be considered for habitat enhancement (e.g., spawning area, access for spring spawning fish species) if suitable outflow conditions are present.

5.8.3 *Summary of Residual Impacts*

The impacts of the Solv-Ex Experimental Co-production Project on the aquatic habitat and associated fish populations and other aquatic resources during the Life of the Project and Post-Operation are summarized below.

Wastewater and mine-pit basal groundwater will be collected and ultimately released to the Athabasca River. All release water will meet Alberta Environmental Protection standards, therefore negligible effects on fish and aquatic resources are expected.

Water withdrawal and intake facilities will result in some entrainment and mortality of small fish or drifting eggs and fry; however, protection measures such as screening will reduce potential losses and the effect would be negligible. Reductions to flow of the Athabasca River during January (the low flow month) as a result of water withdrawal for the Solv-Ex project, or for the Solv-Ex, Syncrude and Suncor projects in combination (cumulative effects) are minor, ranging from 0.1 to 0.2%, respectively. The reductions in flow will not negatively affect fish or other aquatic resources.

Life of Operation:

- Additions of sediment from construction activities and surface drainage to the Athabasca River may decrease local aquatic habitat capability and biota. This impact would be Low in magnitude, Negative, Short-term in duration, Continuous during the construction phase, Local in geographic extent and Reversible.

- Additional people associated with the project and improved access along Highway 63 will result in increased fishing pressure and harvest and a decrease fish populations. This impact would be Low in magnitude, Negative, Long-term in duration, Regional in geographic extent and Reversible if populations are not too heavily fished.

- Bank protection/stabilization association with the water intake and the shoreline in the vicinity of the mine along the Athabasca River will result in additional aquatic habitat and increased diversity. This impact would be Low in magnitude, Positive, Long-term in duration, Continuous, Local in extent and Reversible.

Post-Operation:

- Development of an end-pit lake at abandonment will create new aquatic habitat. Restoration/stabilization of river banks and possible local stream enhancement may increase fish and aquatic habitat. Habitat restoration and enhancement would be Positive, Long-term, Continuous and Local (other impact terms are not applicable).

- Continued increase in fishing pressure may result due to improved access. Although this impact is Negative, it would be Low in magnitude, Long-term and Regional (other impact terms are not applicable).

5.8.4 *Fish and Aquatic Resource Monitoring*

Baseline biophysical data on water quality, fish use, aquatic habitat and macrovertebrate fauna of Fort Creek should be collected because of its association with the Solv-Ex lease and project area. The need for subsequent monitoring could then be evaluated.

The potential productivity and suitability of the end-pit lake for fish should be examined prior to abandonment.

5.9 Resource Use

This section summarizes the impacts from the Solv-Ex Development on consumptive resource use including food gathering, timber harvesting, fishing, and hunting and trapping opportunities, and non-consumptive resource use such as photography and recreational activities.

5.9.1 *Food Gathering Opportunities*

Activities associated with Solv-Ex development that will affect food gathering are summarized in Figure 5.24, and include changes to vegetation and changes in site access.

5.9.1.1 Decrease Food Gathering Opportunities

Approximately 294 ha of the vegetation types being cleared in the Local Study Area for the Solv-Ex project support edible plants. These include black spruce (189 ha), aspen (32 ha), aspen/jack pine (25 ha), white spruce (3 ha), white spruce/aspen (3 ha), aspen/white spruce (3 ha) and jack pine (1 ha) (see Section 5.6.1). Previously cleared areas will also be disturbed, including the Bitumount airstrip and the existing Highway 963 right-of-way (37 ha). The plants affected include: labrador tea, cranberry, currant, chokecherry, blueberry, strawberry, kinnikinnick and rose (Table 5.24).

Some medicinal or ceremonial plants such as mint may be lost through clearing operations. Mint has been identified as being in the Local Study Area (Fort McKay Environmental Services Ltd.

Figure 5.24 Improved access, changes in plant vigour and survival, loss of plant communities, and establishment of early and mid-successional plant communities will *change food gathering opportunities such as berry picking.*

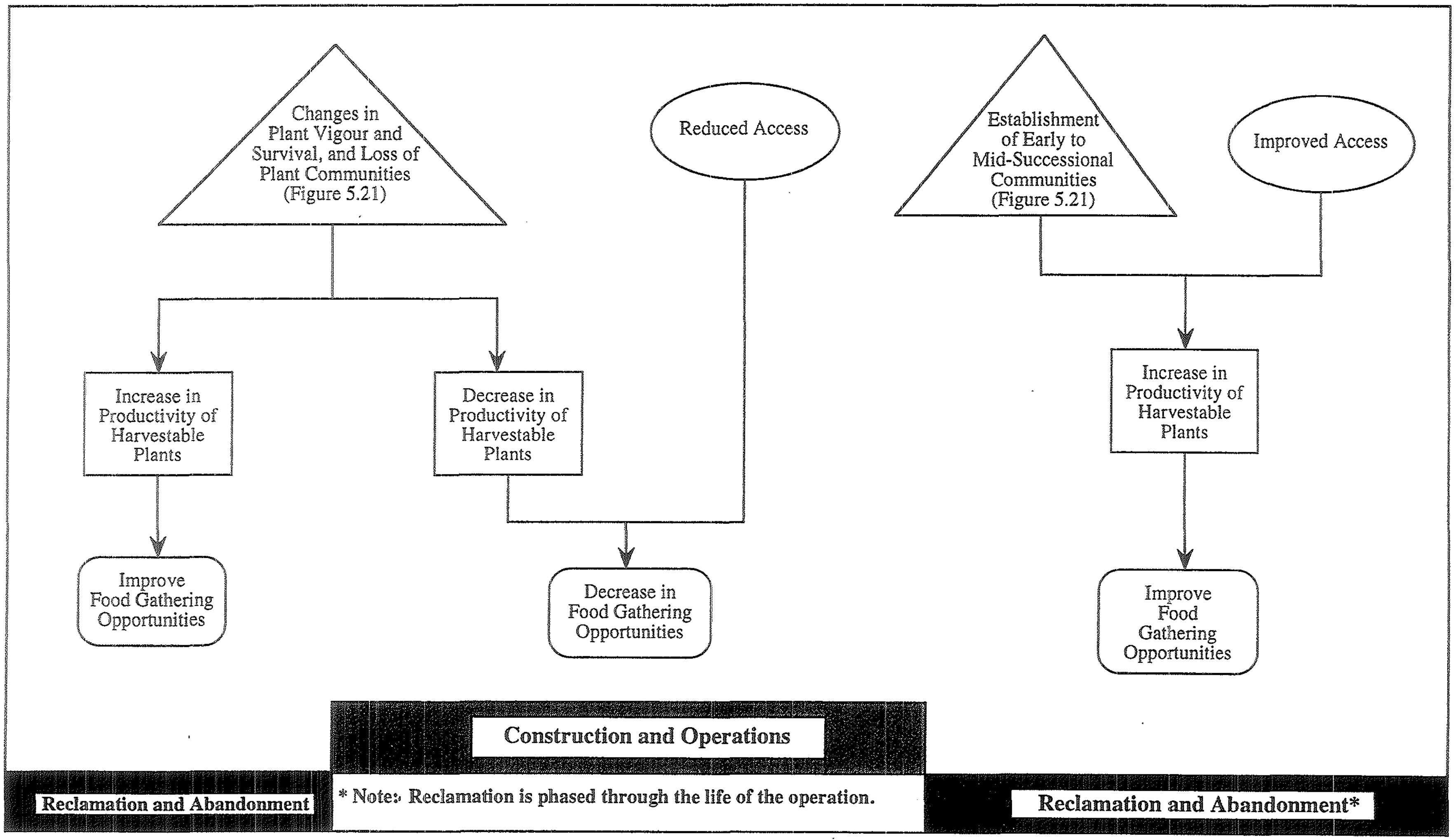


Table 5.24 Edible plants affected by clearing the Solv-Ex development area.

Edible Plants	Vegetation Communities							
	White Spruce	Jack Pine	Black Spruce	Aspen	Aspen/ White Spruce	Aspen/ Jack Pine	White Spruce/ Aspen	Previously Cleared Areas
Blueberry		x		x	x	x	x	x
Chokecherry		x						
Cranberry	x	x		x	x	x	x	
Currant	x		x		x		x	
Kinnikinnick				x	x	x	x	x
Labrador tea	x	x	x		x		x	
Rose				x	x	x	x	x
Strawberry		x				x		x

1995; Appendix VIII), however, its distribution and abundance is not well known. The known location is outside of the area that will be disturbed by the proposed Solv-Ex project.

As noted in Section 5.6.1, within the Biophysical Cumulative Effects Study Area, a total of 2385 ha or 4% of the vegetation has been previously disturbed due primarily to cutlines and wellsite (Table 5.17). The cumulative effect of clearing vegetation for the Solv-Ex project on food gathering opportunities will be 2679 ha (2385 ha plus 294 ha) or 5% of the BCESA.

During construction and operation of the proposed Solv-Ex project, access to the development site will be restricted. Therefore, areas that had previously been used for food gathering will not be available for use.

5.9.1.2 Improve Food Gathering Opportunities

Changes in plant vigour and survival, and loss of plant communities are discussed in Section 5.6.

The reclaimed Development Area will increase the edge area of forest stands and will provide 287 ha (6% of the Local Study Area) of early successional vegetation communities (30 ha of cleared area will be developed into end-pit lake and 14 ha is required for the upgrade of Highway 63). The species that will colonize these areas include strawberry, blueberry, chokecherry and rose. As succession proceeds species such as Labrador tea, currant, cranberry and kinnikinnick will increase in abundance.

Following reclamation, access to the development site will be permitted, which will increase the availability of food gathering opportunities. The upgraded Highway 63 will improve access along an existing route which will increase the ease of food gathering activities.

5.9.1.3 Summary of Residual Impacts

The residual impacts of the Solv-Ex Experimental Co-production project on food gathering opportunities during the Life of the Project and Post-Operation are summarized below.

Life of Operation:

- The removal of 294 ha of vegetation that support edible plants and the restricted access to areas that were once accessible, will have a Moderate magnitude (7% of Local Study Area, or an increase of 1% in the Biophysical Cumulative Effects Study Area), Negative impact on traditional food gathering for the duration of the 7 year project. Access outside of this area along existing routes will be maintained. This impact is Irreversible within the life-span of the project (other impact terms are not applicable).

Post-Operation:

- Reclamation of the Development Area will return 287 ha (6% of the Local Study Area) to vegetation will increase the abundance of early to mid succession plants including strawberry, blueberry, chokecherry, rose Labrador tea, currant, cranberry and kinnikinnick. This will positively increase early successional edible plants for a period >7 years, however, the impact of the initial clearing is irreversible over the life of this project (Long-Term).

5.9.1.4 Resource Use Monitoring

No monitoring programs beyond those identified for soil and vegetation (Sections 5.5.2.4 and 5.6.5) are recommended.

5.9.2 *Timber Harvesting Opportunities*

Activities associated with the Solv-Ex development that will affect timber harvesting opportunities are summarized in Figure 5.25.

5.9.2.1 Decrease in Timber Harvest Potential

Approximately 296 ha of forest will be cleared for the Solv-Ex project. This will include 67 ha of productive forest and 229 ha of non-merchantable vegetation, and result in the removal of 6500 m^3 of wood volume. Average timber volume is 22 m^3/ha. Where feasible, all merchantable timber will be salvaged for pulp wood and sawlogs in accordance to the requirements specified by the Alberta Forest Service. Merchantable wood includes all timber stands with a minimum of 50 m^3/ha of gross timber volume based on a 15 cm butt diameter and 11 cm top diameter.

The 50 ha mine site will be taken out of production for approximately 5 years while the plant, overburden and tailing piles will be removed from production for 7 years. For the mine site, the loss of production for the 5 year period will be approximately 355 m^3 based on the average growth rate for each timber type (Section 4.9). The impact of site clearing will result in a reduction of the annual growth of < 1% of the coniferous and < 1% of the deciduous timber.

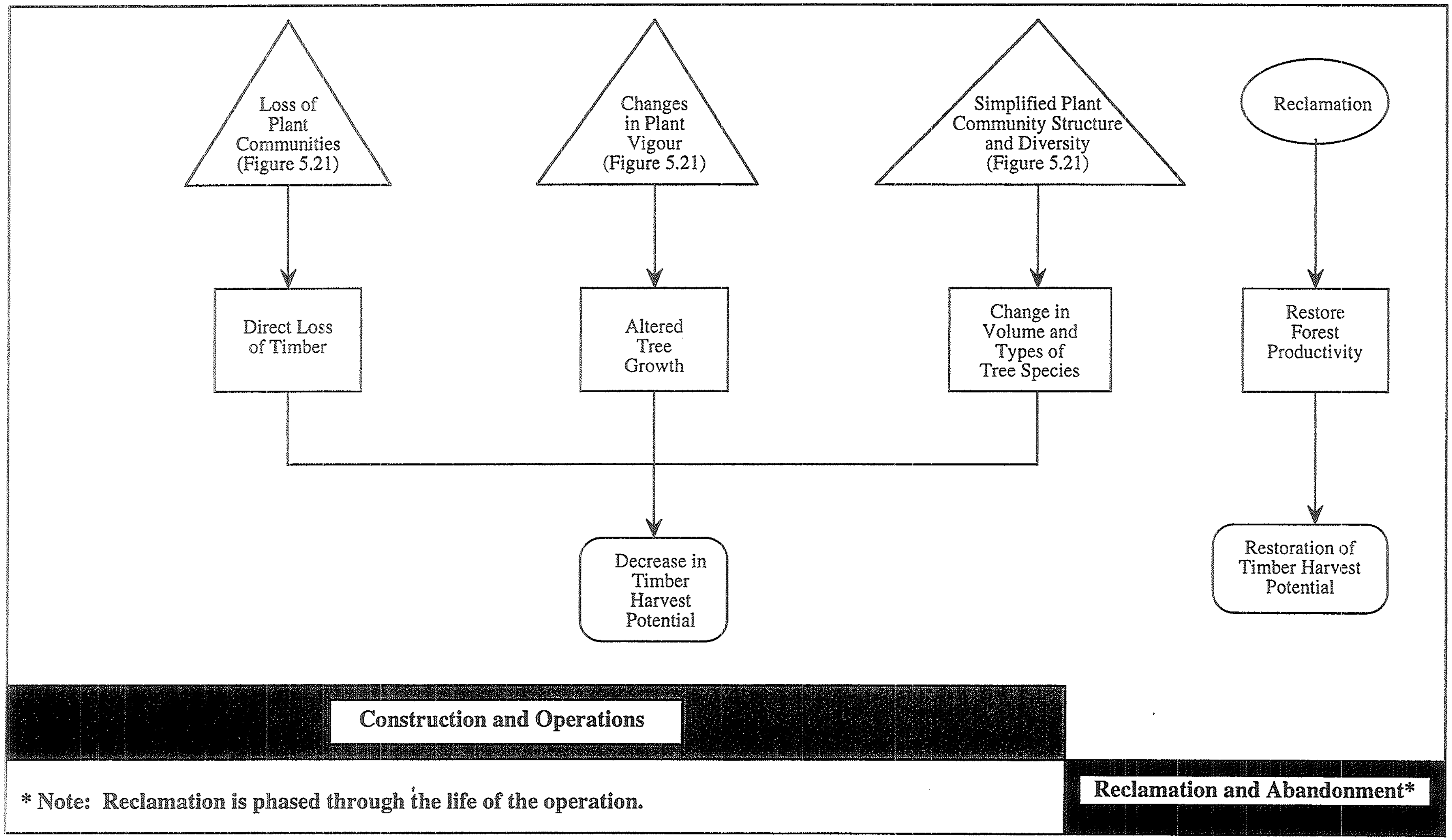
The Solv-Ex project is located in the Forest Management Area of Alberta Pacific (Al-Pac). Solv-Ex will negotiate compensation with Al-Pac for the loss of merchantable timber between 1995 and 2002.

SO_2 and NO_x concentrations resulting from the Solv-Ex project are not predicted to have direct or indirect (e.g., through water or soils) effects on vegetation. Predicted concentrations are within the WHO and IUFRO guidelines specified to maintain forest vegetation health. However, the interactive effects of SO_2, NO_x and O_3 on plant growth and yields are difficult to predict due to the variability of responses amongst plant species and to various concentrations (Undetermined Impact) (Section 5.6.2.3).

5.9.2.2 Restoration of Forest Productivity and Timber Harvest Potential

Reclamation of the mine area will begin in 1998 and will be phased during the operating period. At the completion of the mining, the 30 ha end-pit will be filled with water to create a lake. The

Figure 5.25 **Loss of plant communities, changes in plant vigour, simplified plant community structures and diversity, and reclamation will** ***change the timber harvest potential.***



reclaimed mine area of 20 ha will be revegetated to coniferous (15 ha), deciduous (3 ha) and mixedwood (2 ha) forests. This will return 60% of the current forest capability to the mine area.

At the completion of the Solv-Ex project, reclamation of the development area (minus the mine site and Highway 63) will return 267 ha of land to productive forest. The forest communities replaced will include aspen (124 ha), mixedwood forest (121 ha) and coniferous forests of white spruce, jack pine and black spruce (22 ha) (Table 5.19). This will increase productive forest land for the total area (including the mine site) by approximately 400%. Forest regeneration to commercial standards will require 50 years for aspen and 80 to 100 years for coniferous species.

A mosaic of vegetation communities, similar to that found prior to disturbance, will be recreated. This will include the restoration of the shrub and herbaceous species contained within the white spruce, aspen and jack pine series of vegetation communities. This is intended to restore some of the ecosystem elements to the reclaimed area.

5.9.2.3 Summary of Residual Impacts

The residual impacts of the Solv-Ex project on timber harvesting, during the Life of the Project and Post-Operation phases are summarized below:

Life of Operation:

- Approximately 296 ha of forest will be cleared within the Local Study Area. This will include 229 ha of non-merchantable and 67 ha or 6500 m^3 (2% in Local Study Area) of merchantable timber. An additional 355 m^3 of timber volume will be lost from the mine area. Merchantable wood will be salvaged. The disturbance will be phased and due to timber salvage, is classed as Low in magnitude, Negative, Irreversible, Long-term and Local in scope.

- The areas cleared for development will not be regenerated to productive forest during the life of the operation, except for 20 ha of the mine. This Moderate magnitude, Negative impact is a single occurrence with Long-term, Irreversible effects.

Post-Operation:

- Reclamation of the Lease 5 Development Area will return 287 ha of land to productive forest. Merchantable timber volumes will return in 50 years for aspen and between 80 and 100 years for coniferous species. Timber volume regeneration is predicted to have a 400% increase. This impact will be Positive, Moderate in magnitude, Long-term, and Local in scope. The impacts are Irreversible for a period of greater than 10 years.

5.9.2.4 Resource Use Monitoring

No monitoring programs beyond those identified for vegetation (Section 5.6.5) are recommended.

5.9.3 *Fishing Opportunities*

Activities associated with the Solv-Ex development that could affect fishing have been outlined in Figure 5.26.

5.9.3.1 Decreased Fishing Opportunities

Access by the public to portions of the Solv-Ex Development Area will be restricted during mine site construction, operation and decommissioning. However, because access prior to development has been limited to a summer trail and to the Athabasca River, fishing in the area has been limited and exclusion from use of the area will affect very few fishermen.

There should be no change in the abundance of fish in the Athabasca River over the Life of the Operation (Section 5.8.3), therefore, fishing opportunities should not decline over this time frame.

5.9.3.2 Improved Fishing Opportunities

After the Solv-Ex Development Area has been reclaimed, access to the east side of the Athabasca River will be improved above that available during pre-disturbance times, due to upgrading of Highway 63 and the winter road. This could result in additional sport and domestic fishing opportunities in the vicinity of the Local Study Area.

Development of an end-pit lake in the mine will create lake habitat, which will likely support a variety of forage fish species and may support populations of sport or domestic fish species (Section 5.8.2). If populations of management-important species develop, then definite increases in lake-based fishing opportunities may occur.

5.9.3.3 Summary of Residual Impacts

The impacts of Solv-Ex project on fishing opportunities during the Life of the Operation and Post-Operation phases are described below. There will be a very limited decrease in fishing opportunities within the Local Study Area due to restricted access; therefore, this impact is considered negligible.

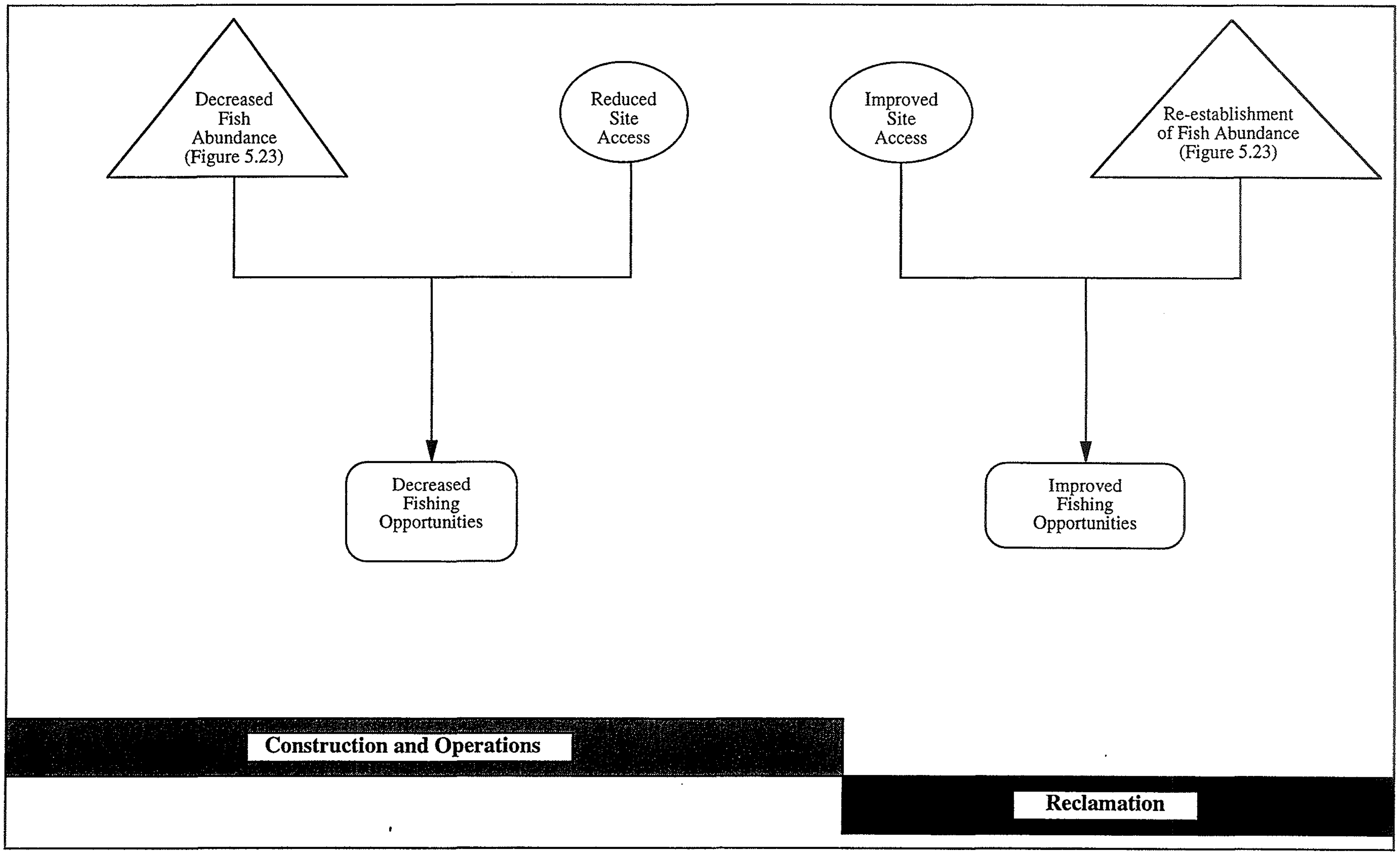
Life of Operation:

- None.

Post-Operation:

- There is expected to be an increase in fishing opportunities in the Local Study Area after reclamation primarily due to creation of the end-pit lake and improved access. This impact is considered Low in magnitude, Positive, Long-term in duration and Local in scope (other impact terms are not applicable).

Figure 5.26 Changes to site access and in fish abundance will *change fishing opportunities.*



5.9.3.4 Resource Use Monitoring

No monitoring programs are recommended beyond those identified for fish resources (Section 5.8.4).

5.9.4 *Hunting and Trapping Opportunities*

Activities associated with the Solv-Ex development that could affect hunting and trapping have been outlined in Figure 5.27, and include changes in abundance of wildlife and changes in site access.

5.9.4.1 Reduced Hunting and Trapping

Access by the public to portions of the Solv-Ex Development Area will be restricted during mine construction, operation and decommissioning. However, because access prior to development has been limited a summer trail and to the Athabasca River, hunting in the area has been limited and exclusion from use of the area will affect very few hunters. Fort McKay Environmental Services (1995; Appendix VIII) states that the BCESA receives little use from local hunters and gatherers because of the increase in use by transient hunters and campers from further south (increases the probability of hunting accidents and unpleasant interactions). Of the land to which access would be restricted, all is currently allocated for trapping under Registered Trapping Areas. The trappers of these RTA's will be fully compensated by Solv-Ex for the loss of trapping opportunities.

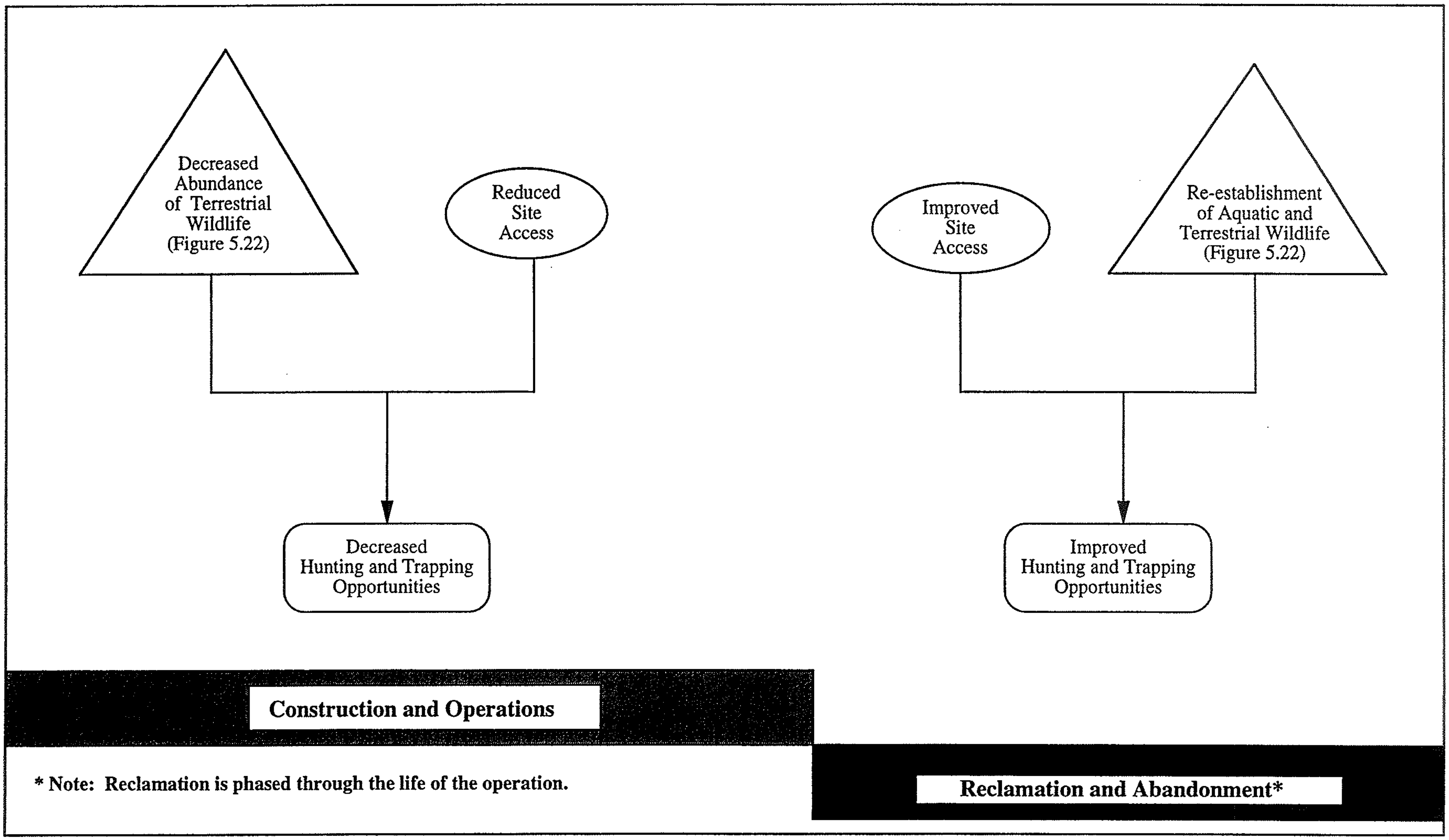
Some terrestrial wildlife species, such as moose, marten and coyotes, with large home ranges, will be displaced from the Solv-Ex Development Area due to vegetation clearing and habitat alienation. Species with smaller home ranges such as grouse and red squirrel, may suffer some mortality. This slight decrease in the abundance of some wildlife species may reduce some hunting opportunities for the public, and trapping opportunities for the registered trappers over the moderate- to long-term (depending on when population levels of various species recover).

As noted in Section 5.6.1, within the Biophysical Cumulative Effects Study Area, a total of 2385 ha or 4% of the habitat has been previously disturbed (Table 5.17). The cumulative effect of clearing habitat for the Solv-Ex project will be 2716 ha or 5% of the BCESA. Therefore, the incremental reduction in hunting opportunities in the region, due to the Solv-Ex project, should be minimal.

5.9.4.2 Improved Hunting and Trapping

After the Solv-Ex Development Area has been reclaimed, access to the east side of the Athabasca River will be improved above that available during pre-disturbance times due to the upgrading of Highway 63 and the winter road. Several authors have reported that the majority of ungulate hunting is concentrated close to roads and trails (80% of the hunting effort and 23% of total kills occurred within 1.6 km of the road, Lynch 1973; 81 to 84% occurred within 300 to 400 m of roads or trials, James *et al.* 1964). Therefore, the construction of the new road will improve access, and hunting and trapping opportunities.

Figure 5.27 Changes to site access and in the abundance of wildlife will *change hunting and trapping opportunities*.



There will be a change in the composition of species using the post-development landscape compared to the pre-development site, until the reclaimed area has succeeded to mature forest cover, and climax wildlife species can reinvade the area. Species associated with early to mid successional habitats (such as moose, black bear, sharp-tailed grouse and hare) and disturbed sites (such as coyotes) will become re-established within the reclaimed landscape. Hare and bear are expected to reinvade the site within several years, moose within 10 to 15 years and red squirrel not for 40 to 60 years.

With the creation of an end-pit lake, there will be a net gain of aquatic habitat and some game species such as beaver or waterfowl.

5.9.4.3 Summary of Residual Impacts

The residual impacts of the Solv-Ex Project on hunting and trapping opportunities during the Life of the Operation and Post-Operation phases are described below.

Life of Operation:

- There is expected to be a slight decrease in hunting and trapping opportunities in the vicinity of the Local Study Area due to the reduced abundance of terrestrial wildlife and secondarily to reduced access. This impact is considered Negative, Low in magnitude, Local to Regional in scope, Long-term in duration, and Irreversible.

Post-Operation:

- There is expected to be an increase in hunting and trapping opportunities due to the increased abundance of terrestrial game species, and possibly aquatic species, using the reclaimed Development Area. Improved access to the site will be available along Highway 63 and the upgraded winter road. This impact is considered Low in magnitude, Positive, Long-term in duration and Local in scope (other impact terms are not applicable).

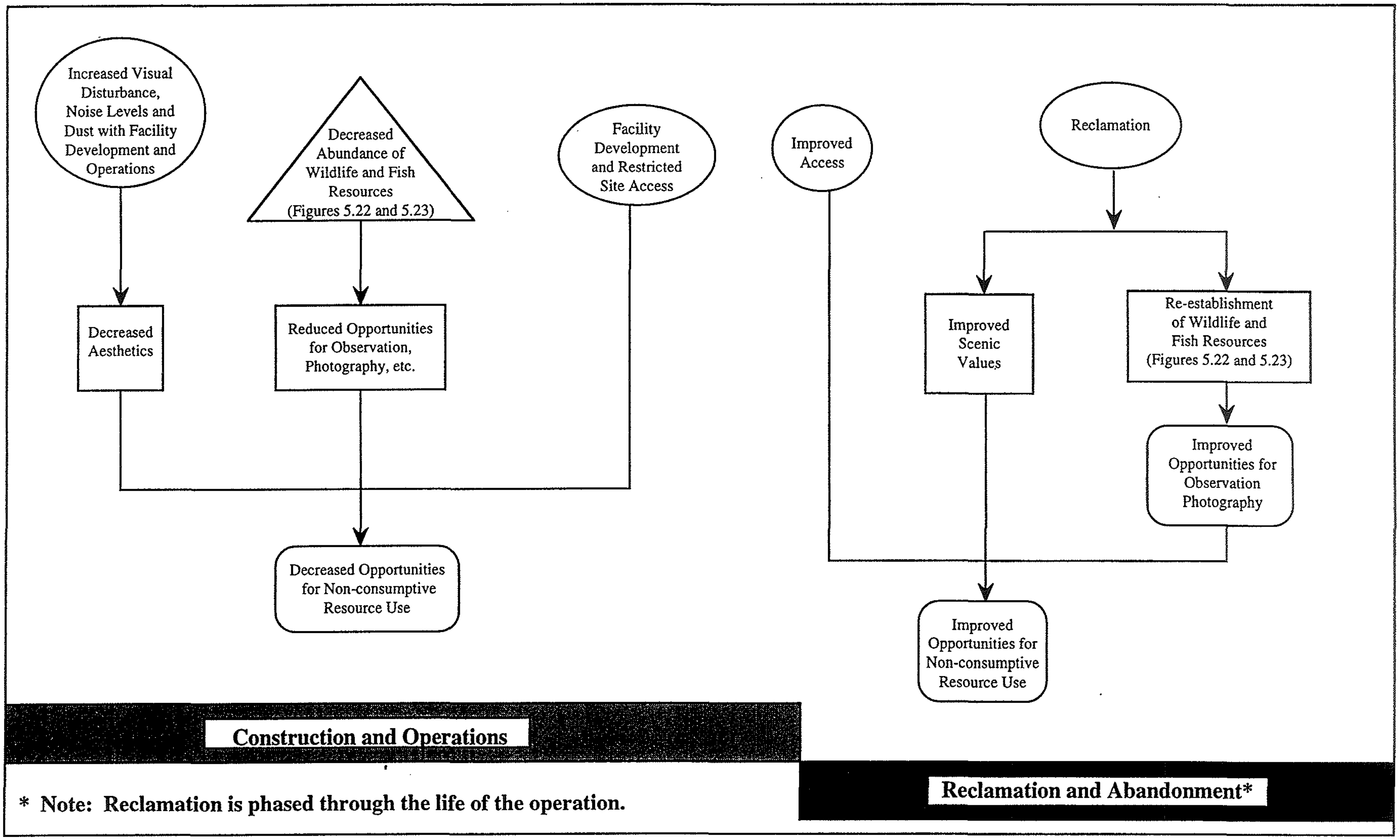
5.9.5 *Resource Use Monitoring*

No monitoring programs beyond those identified for wildlife in Section 5.7.5 are recommended.

5.9.6 *Non-Consumptive Resource Use*

Activities associated with the Solv-Ex Project that will affect non-consumptive resource use are summarized in Figure 5.28. The proposed Development Area currently receives only low non-consumptive use.

Figure 5.28 **Increased noise and dust, decreased abundance of wildlife and fish, and facility development (during the construction and operations phase) and improved access and reclamation (during the reclamation and abandonment phase) will *change non-consumptive resource use.***



5.9.6.1 Decreased Aesthetics

The construction of the Solv-Ex facilities will have an impact on aesthetics through the removal of vegetation, the improvement of the road, the installation of a water intake structure and pipeline, the construction of plant buildings and the storage of overburden materials, tailings and sulphur.

- The primary visual impacts will include the mine site, plant facilities, water intake structure and overburden and tailings piles.

- Secondary visual impacts will include dust, either from the mine or roads, the sulphur block (during the first year of operation) and exhaust from the stacks (particulates or ice fog).

- Facilities will be visible from the access points to the development area, the river, Highway 63 and the upgraded winter road, and from surrounding heights of land such as the Fort Hills. The water intake on the Athabasca River will be bermed and screened with vegetation to substantially reduce the aesthetic impacts. To minimize the visibility of new facilities from the river, a berm will be constructed and vegetation screen grown, if necessary. The Bitumount Historic Site will be buffered from the mine and plant sites by spruce and aspen forests, although visitors will pass by the Solv-Ex facilities when they travel by road to this Historic Site.

Noise will be maintained within levels identified in the AEUB Noise Directive (see Section 5.2.6) There are no residences within that area and the spruce, aspen and pine forests (heights up to 18 m) between the mine and plant sites, and the Athabasca River are expected to reduce the noise levels at the water level of the Athabasca River. Noise impacts will include those created during vegetation clearing, mining, plant operation and by increases in vehicle traffic. An electric motor will power the pump to remove water from the Athabasca River which will cause minimal noise disturbance. Construction activities will increase noise levels which will subside when plant operation begins.

5.9.6.2 Reduced Opportunities for Observation, Photography, etc. and Restricted Access

Decreased abundance of wildlife and fish resources during the Life of the Operation are discussed within Sections 5.7 and 5.8.

The alteration of vegetation through the clearing of 331 ha (7% of the Local Study Area) will include 256 ha of forest (black spruce 74%, aspen 13%, aspen/jack pine 10%, white spruce 1%, aspen/white spruce 1%, white spruce/aspen 1% and jack pine < 1%), 37 ha of fen and 37 ha of previously disturbed vegetation including portions of the Bitumount airstrip and the Highway 63 corridor. Observation and photography opportunities for natural vegetation will be affected in the area of the mine and plant sites only.

The Bitumount Historic Site will not be affected by the development.

During construction and operation of the proposed Solv-Ex project, access to the development site will be restricted. Therefore, areas that had previously been used for non-consumptive resource activities will not be available for use.

5.9.6.3 Improved Scenic Values

Vegetation similar to the cleared plant communities will be replaced during reclamation. This will include 127 ha of aspen, 123 ha of mixedwood and 37 ha of coniferous forest communities. The mine site, overburden pile and Highway 63 will be the only facilities that will continue to cause a visual impact following reclamation. The mine site and overburden pile will be landscaped and contoured to provide for desirable attributes for wildlife and aesthetics. A 30 ha end-pit lake will be created.

The increased abundance of wildlife and fish resources as a result of site reclamation (Sections 5.7 and 5.8) will increased opportunities for photography, etc.

Following reclamation, access to the development site will be permitted and the upgraded Highway 63 will improve access, thus increasing non-consumptive resource use opportunities.

5.9.6.4 Summary of Residual Impacts

The residual impacts of the Solv-Ex project on aesthetic impacts during the Life of the Project and Post-Operation phases are summarized below.

Noise will be maintained within levels identified in the AEUB Noise Directive, and there are no residences within 1.5 km from the plant site. Further, the forest vegetation (up 18 m in height) surrounding the plant and mine site will attenuate the sound from the operations.

Life of Operation:

- Visual impacts will include the removal of 331 ha (7% of the Local Study Area) of forest cover and infrastructure development, mining activities, the development of overburden and tailings piles, and air emissions (including ice fog during the winter and sulphur dust during the first year of operation). Solv-Ex facilities will be visible from the upgraded Highway 63 and upgraded winter road. To reduce visibility of the development from the Athabasca River, a berm/vegetation screen will be developed. This Irreversible, Negative impact will occur continuously during the life of the project (Moderate duration), and is considered Low to Moderate in magnitude (other impact terms are not applicable).

- There will be some reduced opportunities for photography and wildlife viewing due to reduced numbers of wildlife and fish, and restricted access. This impact is considered Low in magnitude, due to the low non-consumptive use of site prior to development. These Irreversible, Negative impacts will occur continuously during the life of the project (Moderate duration; other impact terms are not applicable).

Post-Operation:

- The reclaimed landscape, increased abundance of wildlife and fish populations, and improved access will provide increased opportunities for non-consumptive resource use and improve aesthetics. This impact is considered Positive, Low to Moderate in magnitude, Long-term and Irreversible (other impact terms are not applicable). The Positive and visual impacts will be a Long-term duration. This impact is Irreversible and will be continuous.

5.9.6.5 Resource Use Monitoring

No monitoring programs beyond those recommended for vegetation (Section 5.6.5) are recommended.

6.0 DESCRIPTION OF BASELINE HISTORICAL RESOURCES

The following report is based on the previous research and the results of previous impact assessment studies associated with highway construction and bituminous sand lease exploration and development. The Historical Resources Impact Assessment Program was prepared without the benefit of First Nation perspective on traditional sites of concern and cultural properties. Similarly, Schedule A was not received from Alberta Community Development detailing their concerns with the site of Bitumount. Input from First Nations and Alberta Community Development is required prior to finalization of the historical resources management program.

6.1 Prehistoric Regional Context

The regional context for historical resources, for the Solv-Ex Project will be defined as the Clearwater Lowland which comprises the lowlands adjacent to the Athabasca River and contained by the tablelands of the Birch Mountains to the west, the Thickwood Hills to the southwest and Muskeg Mountain to the east (McPherson and Kathol 1977). Within the Clearwater Lowlands there is relatively little detailed information regarding the length of human occupation or the nature and content of remains attributable to such occupation. Of the approximately 350 sites which have been recorded in the Clearwater Lowland, only three have been sufficiently studied to provide data which is useful in describing prehistoric use of the area. The sites consist of the Cree Burn Lake Site (HhOv 16) opposite Fort McKay, the Bezya Site (HhOv 73) in the Alsands Lease, and the Beaver River Quarry Site (HgOv 29) in the Syncrude lease (Figure 6.1).

6.1.1 *Cultural Chronology*

Although this area could potentially have been available for occupation approximately 11 000 years ago, immediately upon the retreat of the Laurentide ice sheet, sites with good relative or absolute dates for early occupation are notably lacking. A projectile point stylistically comparable to Agate Basin forms was found at the Beaver River Quarry identified by Syncrude Canada Ltd. in 1973 and excavated in 1974. The site is located at the confluence of the Beaver and Athabasca rivers. Archaeological excavations at this site produced over 30 000 artifacts, all of Beaver River Sandstone. Based on dates associated with the Agate Basin projectile point style to the north and northwest, the use of this site may extend back 8500 years (Clark 1991). Evidence for later occupation, as suggested on the basis of typological similarities of projectile points from the northwestern plains, is also present, primarily as isolated specimens from different sites. For example, evidence of middle period occupation is based on Duncan, Oxbow and Besant projectile point forms. Associated artifacts from these sites are of a generalized nature with little interpretive potential relating to specific activities or aspects of lifestyle.

Only two sites are associated with radiometric data. Occupation 2 in area D (mouth of Mill Creek) of the Cree Burn Lake Site has been dated to 1240) 60 B.P. (Head and Van Dyke 1990). The remaining data was obtained on the Bezya Site. Dated to 3990)170 B.P., this site was excavated by the Archaeological Survey of Alberta (LeBlanc and Ives 1986). Unique to this site are chert microblades and cores. The raw material is significant in that it differs from the Beaver River Sandstone characteristic of the majority of sites in the Clearwater Lowland. Microblade technology

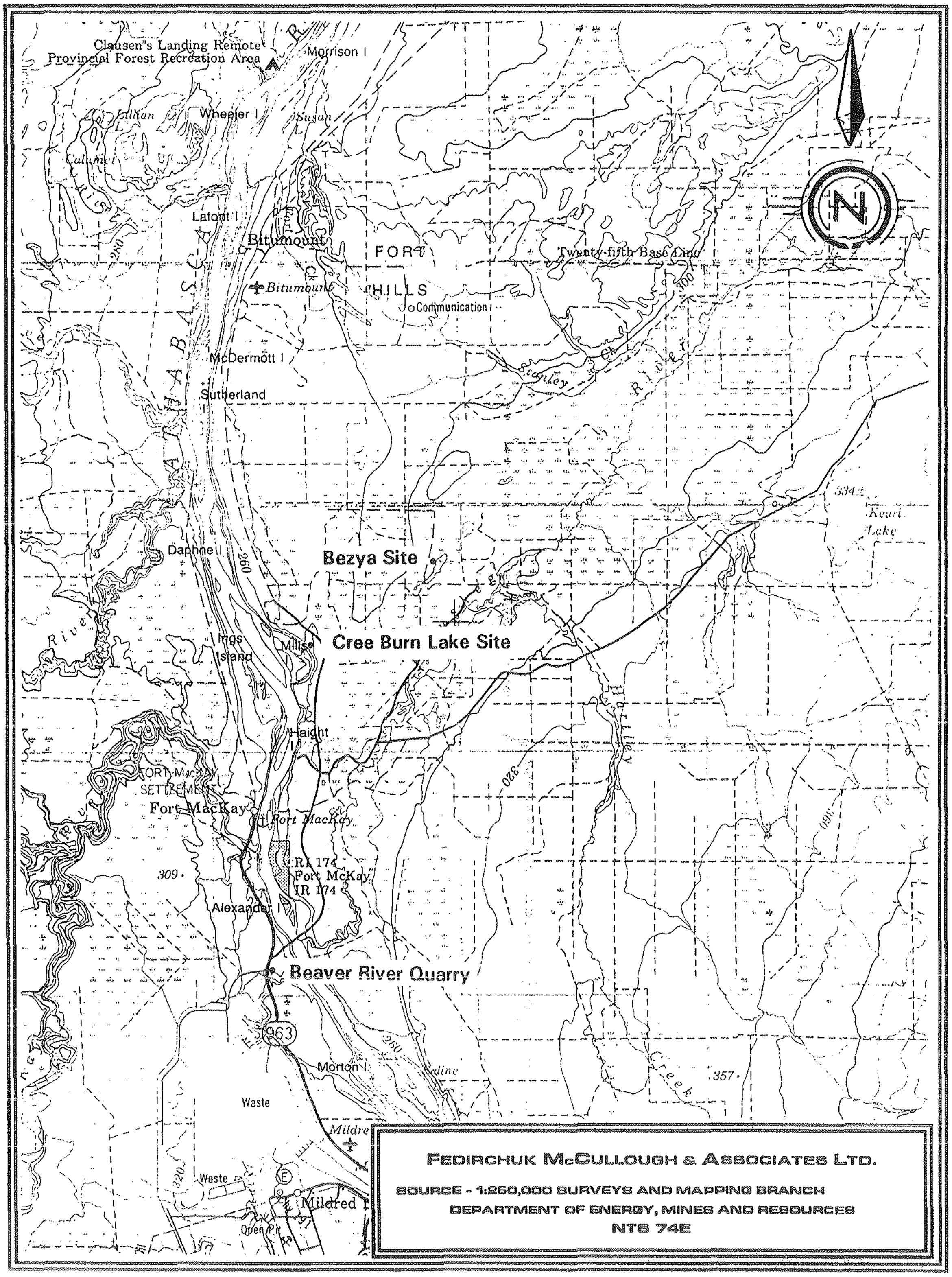


Figure 6.1 Significant sites in the Clearwater Lowlands.

has been reported from only two other sites in northern Alberta, Peace Point in Wood Buffalo Park (Stevenson 1986) and Fort Vermilion (Pyszczyk 1991). Potentially related material may occur in the Clearwater Lowlands at HhOv 3 where a burin was recovered by Sims (1977). Because the burin is an isolated specimen, it is difficult to interpret the site in the context of the study area. To the northwest, both microblade and burin technology is present in archaeological sites near Pointed Mountain (Millar 1970; 1971; Fedirchuk 1975) in the Northwest Territories and in northwest British Columbia (Smith 1970, 1971; Fladmark 1982). The Pointed Mountain sites date from about 4000 to 1000 B.C. Identification of sites with this cultural affiliation in the Fort McMurray area is significant as it suggests either direct cultural ties or communication networks with areas to the west and northwest during the prehistoric era.

Archaeological studies at the Cree Burn Lake Site have been largely mitigative in character and restricted to perceived highway construction impact. As such, detailed information on the extent, complexity, and content of the site is limited. Surface collections along the highway corridor and from limited excavations (Head 1979*a*, 1979*b*; Mallory 1980; Reeves and McCullough 1978; Ronaghan 1981*a*, 1981*b*; Sims 1975) consist mainly of undifferentiated chipping waste (Ronaghan 1981*b*; Head and Van Dyke 1990) with bifaces and bifacial fragments and retouched flakes of Beaver River Sandstone representing the few associated finished tools (Head and Van Dyke 1990). In general assemblage composition and the raw material the site resembles the Beaver River Quarry (Head and Van Dyke 1990).

To date, the recorded sites have been not affiliated with any specific First Nations in the area, i.e. Slave, Beaver, Chipewyan or Cree groups, who occupied the area during the fur trade era, but are viewed as the product of Athabaskan/Algonkian speakers. Because few archaeological sites in the Clearwater Lowlands have been excavated, little is known about the true temporal span of occupation, technological continuities and innovations, and cultural changes which are characteristic of the study area.

6.1.2 *Raw Materials*

The majority of sites within the Clearwater Lowland are artifact scatters, i.e. small scatters containing less than 25 artifacts, which represent mainly chipping waste of Beaver River Sandstone. Although the source for Beaver River Sandstone undoubtedly occurs in the Fort McMurray area, artifacts made of Beaver River Sandstone have been found at the Duckett Site on Ethel Lake (Fedirchuk and McCullough 1993), on the shores of Lac La Biche, and possibly as far south as the Milk River. This distribution indicates the extent of prehistoric trade patterns in which Beaver River Sandstone played a role.

The lithic material is likely derived from the McMurray Formation (McCullough and Wilson 1982, Ives and Fenton 1983). Although the Beaver River Quarry was initially identified as the primary source for the archaeological collections in the Fort McMurray area, further analysis of the artifacts from the surrounding sites and from the quarry indicates that the Beaver River Quarry is not the source of the fine grained Beaver River Sandstone which predominates in the sites in the Clearwater Lowland. The lithic materials on which artifacts at the surrounding sites are made, represent a much finer grained material than 99.9% of the lithics present at the quarry (Reardon 1976). As such, it appears that only a very small fraction of the total number of artifacts made of

Beaver River Sandstone in sites in the Fort McMurray region are derived from the Beaver River Quarry. It is increasingly evident that there is an alternate and superior source for Beaver River Sandstone. It is currently believed that the source lies at or near the Cree Burn Lake Site (Ives and Fenton 1983, McCullough and Wilson 1982).

The Cree Burn Lake Site is the most areally extensive site in the region, cultural material being exposed over an area two kilometers in length paralleling a lenticular oxbow lake on the east side of the Athabasca River. Artifacts recovered from the site consist predominantly of fine grained Beaver River Sandstone. The lateral extent of the site is significant in that it is indicative of a focal point for lithic processing. The large quantities of high quality Beaver River Sandstone suggest that a major source is located in either the immediate vicinity or perhaps within the limits of the site area. The high density of sites, all containing large quantities of similar quality material, in the surrounding area supports this contention.

6.2 Historical Context

Between 1775 and 1779, Peter Pond and the Frobisher Brothers entered the Athabasca district. According to Campbell (1954: 42), Pond was the first white man to cross the Methye Portage in 1778, having been sent by the Saskatchewan Free Traders into the Athabasca region. He constructed what was to become known as 'Old Establishment' about 40 miles above the mouth of the Athabasca River to establish trading relations with the Dene. Eventually, his trading network extended as far north as Great Slave Lake. Although Pond was not a formally educated man, his thirst for knowledge and his keen powers of observation resulted in the first map of the north central parts of Canada.

Following the success of Pond's trading ventures, Fort Chipewyan I (1788-1800), Nottingham House (1802-1806), Fort Wedderburn (1815-21) and Fort Chipewyan II (1800-present) were established on Lake Athabasca whereas numerous secondary trading posts were established along the Athabasca River within the Clearwater Lowland. Between 1788 and 1821 four early posts existed at the confluence of the Clearwater and the Athabasca rivers (Chalmers 1974). Other significant posts in the area include an unnamed post built by John Clark at Fort Creek (1802), Pierre au Calumet (1819-1821), Beren's House (1819-1821) later relocated to the mouth of the McKay River; St. Germain's House (post 1788-1802?), and Fort McMurray established by Moberly in 1870.

The significance of these early trading posts is related to the first white occupation of the area, interaction of the white and native populations, and the resultant change in native lifestyles. Associated with these structures are native encampments and task-specific sites for procurement of supplies for the traders, particularly bison for pemmican and bark for canoes and roofs of trading post structures. The nature of these aspects of history are best reflected in the archaeological remains which are associated with these historic sites.

More recent historic sites are associated with early oil sands exploration and development and with fur trapping activities. Most notable of the early oil sands exploration sites is the Bitumount Oil Extraction Plant, a Designated Historical Resource. Other important sites relating to this early exploration period also exist in the area. In 1906, Alfred von Hammerstein (Parker 1974) drilled the first exploratory well about 15 miles below Fort McMurray. One of these exploration sites was discovered during an Historical Resource Inventory and Assessment of the Core-Hole Drilling Program on Bituminous Sands Lease No. 52 (McCullough 1980) and resulted in the location of the remains of a 1920 drilling operation consisting of two log buildings, two building foundations, a wooden impact drilling rig, steel well casings, and other drilling equipment adjacent to an access right-of-way. The site probably relates to one of the earliest attempts by R. C. Fitzsimmons and his Spokane Athabaska Oil Company Limited and International Bitumen Co. Ltd. to tap the bitumen in the oil sands. This site is of considerable historical significance and some of the equipment has been removed for display at Heritage Park in Fort McMurray.

Throughout this period of resource development, the local native population continued in the fur trapping tradition, temporarily occupying tents and cabins along their traplines in winter and summering along the rivers and nearby lakes where fish were readily available. Sites reflecting their use of the area, potentially including medicinal plant collection and spiritual localities, are expected to exist throughout the Clearwater Lowland.

6.3 Palaeontological Regional Context

The Clearwater Lowland is situated near the eastern margin of the Western Canadian Sedimentary Basin, a broadly synclinal area of Phanerozoic sediments overlying a severely eroded PreCambrian basement complex. PreCambrian rocks are exposed a short distance to the east of the Clearwater Lowland near the Alberta-Saskatchewan border and constitute a portion of the Canadian or PreCambrian Shield.

In the deepest portions of the sedimentary basin, rocks of Cambrian age overlie the PreCambrian 'basement' sequence and represent transgression of oceanic waters over the margin of the PreCambrian terrain. The earliest Devonian group consists of the Elk Point Group, a sequence of formations dominated by evaporite rocks. These sediments, essentially chemical precipitates, reflect deposits in a lagoon behind a barrier reef complex, with restricted water exchange and hence lagoonal brines supersaturated by evaporation. Limestones and shales of the Beaverhill Lake Formation (sometimes referred to as the Waterways Formation) were deposited over the Elk Point beds in more open marine conditions. During the late Paleozoic and early Mesozoic eras, the subsurface evaporates were subjected to chemical solutions by the invasions of surface and formations waters, with the result that collapse features (sinkholes, or karst topography) appeared in the area.

The Lower Cretaceous McMurray Formation is a result of deposition of alluvial sands characterized by lenticular beds of conglomerates, sand and silt (McLearn 1917). It is within these deposits that the bitumen is contained (Alberta Society of Petroleum Geologists 1960). Embedded in the sands of the McMurray Formation are small invertebrate fauna of fresh water origin such as protozoa (Foraminifera) and mollusks (Pelecypoda, Gastropoda) (Carrigy 1959). Fish teeth have also been recovered (Carrigy 1975).

Most of the post-McMurray strata can be assigned to the immediately overlying Clearwater Formation consisting of marine sands and shales, and particularly its lower member, the Wabiskaw member (glauconitic sandstone). Reported marine fauna include protozoa (Foraminifera), mollusks (Pelecypoda, Gastropoda, Cephalopoda), and arthropods (Ostracoda) (Carrigy 1959). Recently, an incomplete Ichthyosaur (Platypterygius) in 1992 and a complete Plesiosaurus in 1994 were recovered from the Wabiskaw member of the Clearwater Formation in the Syncrude lease (B. Nichols, Royal Tyrell Museum, Drumheller, pers. comm. 1995).

Unconsolidated deposits of the Quaternary Period which includes the Pleistocene epoch (Ice Age) and the Holocene epoch (last 10 000 years) represent the surficial materials. During warm interludes of the Pleistocene and early Holocene epochs, Alberta supported a rich and varied fauna including such large mammal forms as mammoth (Mammuthus spp.), giant short-faced bear (Arctodus sp.), camels (Camelops sp.), wapiti (Cervus sp.) and bison (Bison spp.). Bones of these animals are frequently found in old river gravels and sands where eddies concentrated them in rich deposits. Random finds are also commonly found in sands and gravels. The type site of the Calumet member of the Beaver Hill Formation containing fossils of Stropheodontae is located on the left bank of the Athabasca River north of Fort McMurray. Quaternary faunal remains have been collected from the region and include the remains of a proboscidean recovered during mining operations within the Suncor Ltd. lease area (McCullough and Reeves 1978). Invertebrate fossil locales have also been documented along the Athabasca River (Macoun 1877, Bell 1884, Crickmay 1957, Carrigy 1959).

6.4 First Nations

There is no doubt that Athabascan speakers occupied the study area prior to white contact. There are, however, researchers (Russell 1991, Smith 1981) who advocate Cree occupation of the area prior to the historic era. Traditionally, the Cree have been viewed as relatively late arrivals, being the forerunners of the fur trade in the early eighteenth century and displacing the indigenous inhabitants (Fedirchuk and McCullough 1981, McCullough 1982, McCullough and Wilson 1982, Fedirchuk and McCullough 1983). These original occupants would have been the ancestors of the modern bands of Chipewyan, Beaver, and Slave. The study area was the southernmost extension of the Chipewyan and Slave territory whereas Beaver territory extended as far south as the Lesser Slave Lake - Lac La Biche - Cold Lake region. There is no doubt that regular contact occurred between the various Athabascan bands that ranged over this vast region ensuring continuation of a relatively homogeneous cultural tradition over much of northeastern Alberta.

By the time that the first white fur traders had arrived, Mackenzie (1971) noted that the indigenous populations had been displaced west and north by the Cree. The earliest documented penetration of the Cree into the Athabasca River region was recorded in June, 1715 by James Knight, Governor of the Hudson's Bay Company at York Factory (Hudson's Bay Company Archives B.239/a/1). Knight had organized a 'peace mission' to Athabasca Country to quell the hostilities between the Cree and the Athabascan groups. The mission, headed by Stewart and a 'Slave Woman', totalled 150 individuals, primarily Cree. Only Stewart and the Slave woman with a group of ten men and one other small band returned to Churchill a year later. The rest of the initial group, comprised primarily of Cree, did not return. In 1778, Peter Pond arrived and established the first permanent trading post at the forks of the Embarras and Athabasca rivers.

An early document of 1809 (Canadian Archives 1928: Appendix E: 67) records a southward movement of the Chipewyan - Within these thirty years however the Chepywyan tribes have emigrated in considerable numbers from Athabasca and the barren lands... Estimated to consist of about 150 families, they are not such good Deer hunters as the Knisteneaux but depend chiefly for subsistence on the Beaver Hunt & the fish they can catch, at which they are very expert (Canadian Archives 1928; Appendix I: 168). Simpson (Rich 1938: 355) in his journal of 1820, was also of the opinion that the Chipewyan were strangers, arriving from the Barren Grounds to the northeast. By 1905, Morice met people of this group as far west and south as Ile a la Crosse, Cold Lake, and Heart Lake.

According to Moberly (Moberly and Cameron 1929: 148), who built Fort McMurray in 1870, Two small bands of Chipewyans and Crees, totalling sixteen or eighteen hunters, traded at the post, but from these few people I always secured forty to forty-five ninety pound packs of fine furs in the course of a winter. When Mitchell (Graham 1935: 50-57) descended the Athabasca River in 1897, he noted a trapper's cabin above Grande Rapids on the roof of which a number of animal skulls were displayed. He noted that all Indians in the area were Crees but that the inhabitants of the Athabasca lived a more varied life than the prairie Crees, exploiting fish, wild fowl, and moose on the uplands.

In the early twentieth century, a few tents of Chipewyans were reported (Butler 1910: 129-130) along the Athabasca River and according to Seton (1911: 27) the occasional set of tipi poles were seen below Fort McMurray. Butler (1910: 130) described a large lodge made of a dozen moose skins housing 10 to 12 individuals and situated on a tree covered shore. It was being occupied during late February and was heated by a large central hearth. The inhabitants told Butler that since the previous fall, they had killed 10 wood bison and 25 moose near their lodge.

The pattern of bush settlements, with or without an associated trading posts, continued until the 1950s. At this time, primarily because of the institution of compulsory schooling for children and the availability of family allowance and other social assistance programs, the focal point for all residences became the communities of Anzac, Fort McMurray, Fort McKay and Fort Chipewyan (Parker 1980). Only Fort McMurray differed in its fundamental economic orientation. While the other communities continued as primarily trapping and trading centers, Fort McMurray emphasized transportation activities. As a result, the social makeup of the two different types of centers also differed with the trading/trapping centers remaining predominantly native and Metis whereas Fort McMurray acquired a primarily white, 'foreign' population.

Although hunting and fishing continued to form the basis of native economy, some employment was available through the church establishments, for example, fishing, sawmills, and church farms, as well as some wood production for the river steamers.

6.5 Previous Studies

As a result of renewed commercial interest in the bituminous sand lease area in the 1980s, a number of historical resource studies thoroughly reviewed the existing data base and collected new data on the oil sands area (Conaty 1979; Fedirchuk and McCullough 1981; McCullough 1980, 1981*a*, 1981*b*, 1981*c*, 1981*d*; McCullough, Wilson and Fowler 1982; Ronaghan 1981*a*, 1981*b*; Sims 1974, Syncrude 1974). As part of the studies on the Bituminous Sands Leases 33, 92 and 95 for Canstar Oil Sands Ltd., information from previous studies was integrated to provide a comprehensive historical resources perspective on prehistoric and historic settlement patterns and site structure in northeastern Alberta focusing on the Clearwater Lowland (McCullough and Wilson 1982). More recently, baseline studies were conducted on the OSLO project area (McCullough and Fedirchuk 1989) and of the Daphne Lease area (McCullough and Fedirchuk 1986).

6.5.1 *Utility Corridor*

The proposed Solv-Ex utility corridor parallels the east side of Highway 63; it will extend 500 m east of the highway center line. The previously proposed Fort McMurray energy corridor (Figure 6.2) consisted of a corridor almost 600 m wide adjacent to the east side of Highway 63.

Archaeological reconnaissance of Highway 63 between the crossing of the Athabasca River and Bitumount was completed in 1977 (Reeves and McCullough 1978); the segment between Bitumount and McClelland Lake was completed in 1978 (Gryba 1978). An Historical Resources Impact Assessment was conducted of the Fort McMurray energy corridor in 1980 (Ronaghan 1981*b*). Twenty-three sites were identified during these studies in the portion of the energy corridor relevant to this study. In 1978, further studies were conducted at a number of sites adjacent to an oxbow on the Athabasca River which were subsequently, collectively, incorporated into a single designation HhOv 16 (Cree Burn Lake Site) as well as at HhOv 7, HhOv 3, HhOv 4 and HhOv 66 within the right-of-way of Highway 63 (Head 1979*a*, 1979*b*). As a result of recommendations arising out the report on this study, controlled surface collection was conducted at HhOv 16 in 1981 (Ronaghan 1982) and limited excavations were completed at HhOv 16 and HhOv 3 in 1979 (Mallory 1980). Additional excavations were conducted at HhOv 16 in association with gravel source development (Head and Van Dyke 1990). These mitigative studies were specifically associated with the right-of-way of Highway 63.

6.5.2 *Lease 5*

Lease 5, in which the proposed Solv-Ex Co-production Experimental Project is situated, has received only cursory examination for archaeological sites. An Historical Resources Impact Assessment was conducted as part of the core-hole drilling program (McCullough 1981*a*) in association with the NOVA-Petro-Canada Oil Sands Joint Venture on B.S.L. 5. No historical resource sites were identified during the field program.

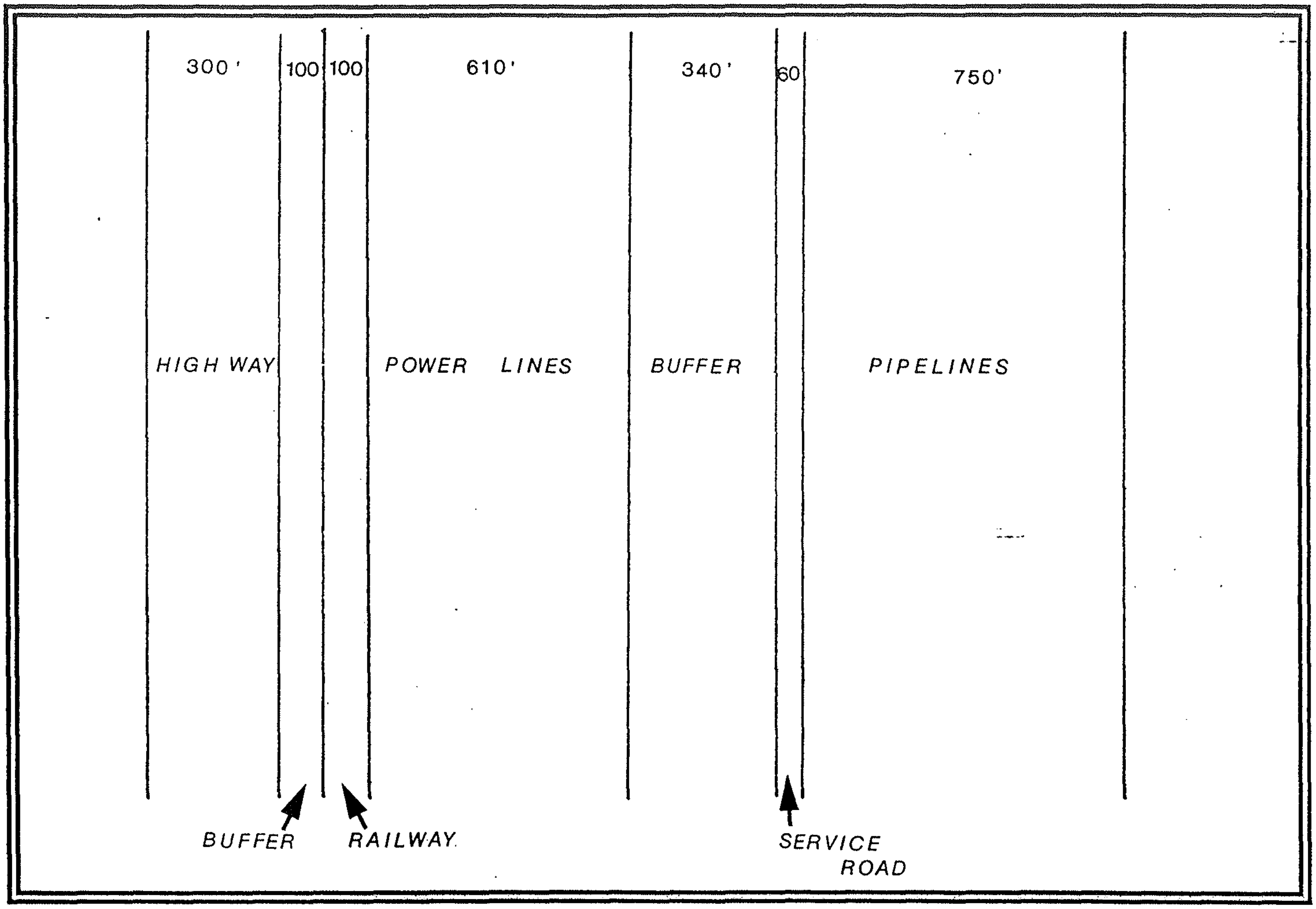


Figure 6.2 Components of proposed energy corridor, 1980.

6.6 Previously Recorded Sites

No previously recorded prehistoric sites occur within the proposed Solv-Ex Development area in Lease 5. Two historic sites are on record for the same area, the provincially owned site of Bitumount and an early oil exploration site recorded by Gryba in 1978.

Twenty-eight previously recorded prehistoric sites are associated with the proposed utility corridor (Table 6.1) between Lease 5 and the southern boundary of Township 95 (Figure 6.3). It should be noted that the location of previously recorded sites, energy corridor boundaries of the Cree Burn Lake Site, HhOv 16, have been expanded and include nineteen previously designated sites (which would have made a total of 47 sites). Of the 28 sites, additional assessment and/or limited mitigative studies were undertaken, relative to the location of Highway 63, at HhOv 16 (Head 1979*a*, 1979*b*; Mallory 1980; Head and Van Dyke 1990), HhOv 3 (Head 1979*a*, 1979*b*; Mallory 1980), HhOv 4 (Head 1979*a*, 1979*b*; Mallory 1980), and HhOv 7 (Head 1979*a*, 1979*b*). Site HhOv 7 has since been included as part of the Cree Burn Lake Site. Based on these studies, it was concluded that all of these sites were significant as they each contained substantial amounts of artifacts, a range of finished tools, and the potential to provide data relevant to the temporal and cultural identify of the occupants. Only at the Cree Burn Lake Site (HhOv 16) were later larger scale mitigative studies conducted relative to the Highway 63 (Ronaghan 1982, Head and Van Dyke 1990). Because extensive surficial disturbance had occurred in the confines of the proposed highway alignment, controlled surface collections were conducted with the objective of providing information regarding internal site structure (Ronaghan 1982: 15) which could be used to devise an effective mitigation program should future development impact the site (i.e. development of the energy corridor). At the conclusion of the study, it was determined that further work was warranted; specifically completion of computer trend analysis of the data collected in that study, comprehensive excavations in both elevated and low lying areas of the site, monitoring of highway construction activities to collect more data regarding artifact distribution across the site, and preservation of intact areas both east and west of the highway alignment.

The study completed by Head and Van Dyke (1990) was associated with construction of the access road between Highway 63 and gravel pit locations but mitigative excavations at HhOv 16 focussed on areas adjacent to Highway 63 and the mouth of Mills Creek. Recommendations arising out of this study included field studies to identify sources of Beaver River Sandstone, extensive shovel testing to identify possible depositional locales for investigation, completion of radiocarbon, and ancillary studies such as blood residue.

Of the remaining 25 sites in the utility corridor, seven sites were recommended for further work. Either controlled test excavation or excavations were recommended at sites HhOv 5, HhOv 111, HhOv 113, HhOv 114, HhOv 115 and HhOv 118 (directly across the highway alignment from HhOv 3 and HhOv 4), and at the early drill well site, HhOv 124.

To date no systematic study of the early explorations sites either in Lease 5 or along the utility corridor have been undertaken. Research at the archives of the Energy Resources Conservation Board was undertaken as part of previous studies in the area on early oil sands exploration activity between the years 1897 and 1925 (Fedirchuk and McCullough 1981, McCullough and Fedirchuk 1989) (Figure 6.4; Table 6.2). Five drill well sites were located within Lease 5. Gryba (1978)

Table 6.1 Previously recorded sites along the utility corridor.

Site Number	Site Type	Site Context	Site Visibility	Geographical Setting	Association	N.T.S. Map Reference	U.T.M. Reference	Recommendations
HhOv 3	Campsite	Disturbed	Fortuitous Exposure	Athabasca River	Sand Ridge	74E/4	12VVU638403	No further study
HhOv 4	Camp/workshop	Disturbed	Fortuitous Exposure	Athabasca River	Sand Knoll	74E/4	12VVU638413	No further study
HhOv 5	Campsite	Disturbed	Fortuitous Exposure	Athabasca River	Knoll	74E/4	12VVU638419	Further study
HhOv 16	Artifact Scatter	Disturbed	Fortuitous Exposure	Cree Burn Lake	Sand Knolls	74E/4	12VVU639446	Further study
HhOv 60	Campsite	Disturbed	Fortuitous Exposure	Athabasca Rver	Ridge	74E/4	12VVU608504	No further study
HhOv 61	Campsite	Disturbed	Fortuitous Exposure	Athabasca River	Ridge	74E/4	12VVU609499	No further study
HhOv 62	Workshop	Disturbed	Fortuitous Exposure	Athabasca River	Ridge	74E/4	12VVU614481	No further study
HhOv 63	Workshop	Disturbed	Fortuitous Exposure	Athabasca River	Ridge	74E/4	12VVU620468	No further study
HhOv 64	Isolated Find	Disturbed	Fortuitous Exposure	Athabasca River	Ridge	74E/4	12VVU637378	No further study
HhOv 95	Artifact Scatter	Undisturbed	Shovel Tests	Athabasca River	Ridge	74E/4	12VVU602516	No further study
HhOv 111	Camp/workshop	Disturbed	Fortuitous Exposure	Athabasca River	Knoll	74E/4	12VVU639404	Test excavations
HhOv 112	Isolated Find	Undisturbed	Shovel Test	Athabasca River	Ridge	74E/4	12VVU644405	No further study
HhOv 113	Camp/workshop	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU646405	Test excavation
HhOv 114	Camp/workshop	Undisturbed	Shovel Tests	Athabasca River	Sand Ridge	74E/4	12VVU644406	Test excavation
HhOv 115	Workshop	Undisturbed	Shovel Test	Athabasca River	Knoll	74E/4	12VVU643408	Excavation
HhOv 116	Artifact Scatter	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU647409	No further study
HhOv 117	Isolated Find	Undisturbed	Shovel Test	Athabasca River	Ridge	74E/4	12VVU639407	No further study
HhOv 118	Camp/workshop	Undisturbed	Shovel Test	Athabasca River	Ridge	74E/4	12VVU639411	Limited excavation
HhOv 119	Artifact Scatter	Disturbed	Fortuitous Exposure	Athabasca River	Knoll	74E/4	12VVU638418	No further study
HhOv 120	Artifact Scatter	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU641422	No further study
HhOv 121	Artifact Scatter	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU645424	No further study
HhOv 122	Artifact Scatter	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU645425	No further study
HhOv 123	Artifact Scatter	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU645426	No further study
HhOv 125	Isolated Find	Disturbed	Fortuitous Exposure	Athabasca River	Sand Ridge	74E/4	12VVU620470	No further study
HhOv 126	Isolated Find	Undisturbed	Fortuitous Exposure	Athabasca River	Sand Ridge	74E/4	12VVU616478	No further study
HhOv 127	Artifact Scatter	Undisturbed	Shovel Test	Athabasca River	Sand Ridge	74E/4	12VVU616478	No further study
HhOv 128	Artifact Scatter	Disturbed	Fortuitous Exposure	Athabasca River	Knoll	74E/4	12VVU699485	No further study
HhOv 145	Drill Well	Undisturbed	Surficial Features	Athabasca River	Knoll	74E/4	-	Further study

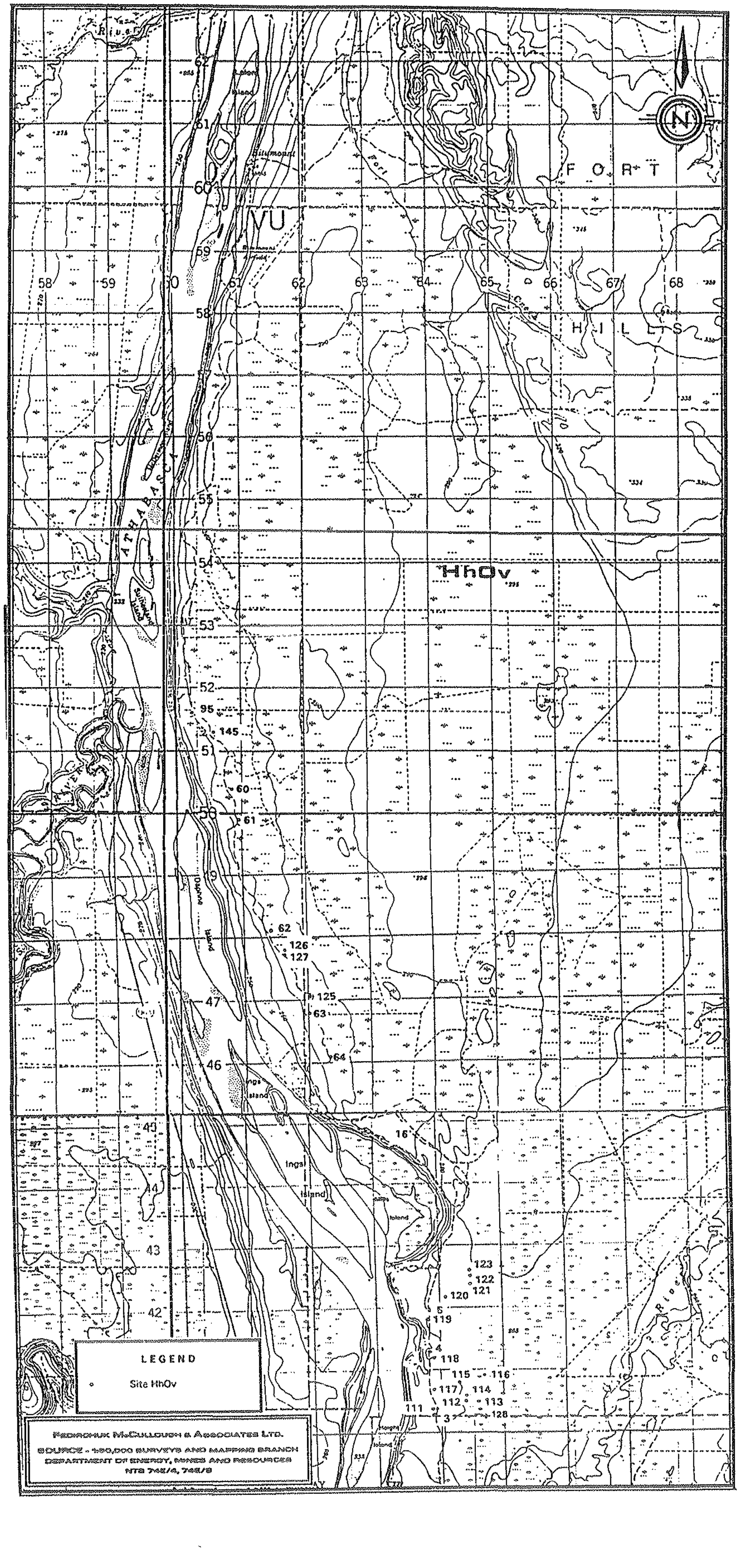


Figure 6.3 Prehistoric sites associated with the proposed utility corridor.

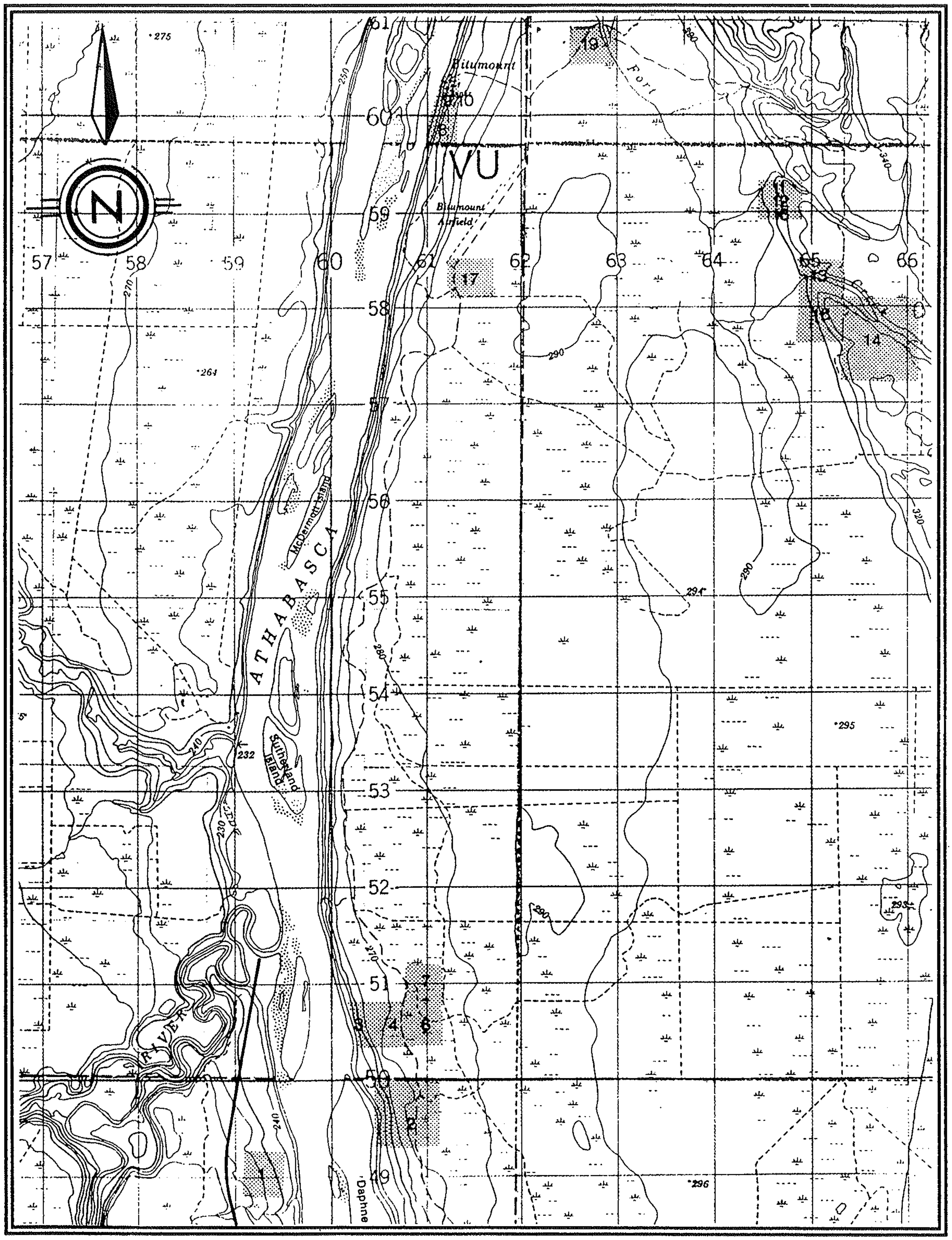


Figure 6.4 Early drill well sites in the vicinity of the project area.

Table 6.2 Early drill well sites in vicinity of project area.

Map #	Well #	Lease #	Company Name	Location	Start Up	Abandoned
1	1	12661	Tekoa Athabaska Oils Limited	LS 6.35.95.11.4	1917	1917
2	-	Ry. Land	Athabaska Oils Ltd.	NW 1/4 36.95.11.4	-	-
3	1	250	Athabaska Oils Ltd.	LS8.2.96.11.4	1911	1914
4	2	250	Athabaska Oils Ltd.	LS5.1.96.11.4	1912	-
5	3	250	Athabaska Oils Ltd.	96.11/10.4	1911	1914
6	4	250	Athabaska Oils Ltd.	LS6.1.96.11.4	1914	1914
7	5	250	Athabaska Oils Ltd.	LS11.1.96.11.4	1914	-
8	1	12633	Spokane Athabaska Oil Co.	LS3.1.97.11.4	1917	-
9	1	12633	Spokane Athabaska Oil Co.	LS6.1.97.11.4	1925	-
10	2	12633	Spokane Athabaska Oil Co.	LS6.1.97.11.4	1925	1925
11	1	13156	Spokane Athabaska Oil Co.	LS10.32.96.10.4	1927	1927
12	1A	13156	Spokane Athabaska Oil Co.	LS10.32.96.10.4	1927	1927
13	2	13156	Spokane Athabaska Oil Co.	LS1.32.96.10.4	1927	1927
14	1	15505	Alcan Oil Corporation	NW 1/4 28.96.10.4	1921	
15	2	15525	Alcan Oil Corporation	LS14.24.96.10.4	1922	1922
16	Test 1	13156	International Bitumen Co. Ltd.	LS10.32.96.10.4	1927	
17	3	13156	International Bitumen Co. Ltd.	LS2.36.96.11.4	1928	1929
18	4	38557	International Bitumen Co. Ltd.	LS 16.29.96.10.4	1928	1929
19	5	12633	International Bitumen Co. Ltd.	LS11.6.97.10.4	1929	1929

identified one of these well sites as part of the highway study. An additional five sites lie either within or in close proximity to the utility corridor. Of these, HhOv 145 is a previously recorded and field verified early oil exploration site in the utility corridor.

6.7 Bitumount

During site selection for a water intake site (Wim Veldman, Hydroconsult EN3 Services Ltd., pers. comm., June 1995), a historic cabin identified as belonging to Bob Fitzsimmons was encountered in the field. This site may represent the "Fitzsimmons camp" established by Fitzsimmons in 1923. To date, the identity of this site has not been verified in the field.

The history of Bitumount reflects the development oil sands exploration and research. Robert Bell (1907: 848) first suggested that the oil sands could be 'mined' and the resultant oil be made available to the consumer public. In the preceding year, Alfred von Hammerstein (Parker 1974: 110-111) who operated a trading post at Baptiste Lake on his own initiative had drilled the first exploratory well about 15 miles below Fort McMurray. In 1907, he acquired 12 000 acres of surface and mineral rights along the Athabasca River on which he (Athabaska Oils Ltd.) drilled a number of additional wells. In 1922, Alcan Oil Company also commenced drilling in Townships 96 and 97, Range 11, three miles east of the Athabasca River (Korvemaker 1973). Robert Fitzsimmons, who visited Alcan's operations, consequently purchased leases adjacent to these holdings. The leasehold included Section 1, Township 97, Range 11, West of the Fourth Meridian, the site of Bitumount (Korvemaker 1973: 8). The following year he purchased Alcan's leases and reorganized the operations under the name of Fitzsimmons. A camp, called Fitzsimmons, was established at the site of Bitumount. A positive result of his venture was the discovery of salt deposits near the Horse River at which a salt plant was later established.

The first systematic mapping and assessment of the bituminous fields was carried out by Sidney C. Ells, who published several articles on his findings (Camsell and Malcolm 1919: 7). He was largely responsible for recognizing the problems in separation of the bitumen and sands, and consequently deflating some of the unrealistic schemes for extraction. According to Parker (1974: 113) approximately 40 holes were drilled between 1897 and 1925 of which only half struck oil sand formations and none were used in successful extraction programs.

At a relatively early date, the University of Alberta began research into methods of extraction and potential uses for the bituminous sands while the Geological Survey of Canada began work on possible extractive methods. In 1936, Abasands Oils Ltd. constructed a plant near the mouth of Horse River at which the tar was removed from the sands. The project was moderately successful in that the diesel fuel product was sold to mining companies although the gas was not considered fit for sale to the general public. In 1942, the Abasands plant was taken over by the Federal Government. It was accidentally burned on June 15, 1945 and the project abandoned. However, the contribution of these early attempts cannot be underestimated.

In 1926, Bob Fitzsimmons had formed the International Bitumen Company and, determined to perfect a viable extraction process, set up a small separation plant at Bitumount which was completed in 1930. After applying to patent his extraction process the following year, he installed a new plant and made plans to build a small refinery. It was 1933 that the site was officially named Bitumount (Korvemaker 1973: 14). The following 10 years were fraught with difficulties, primarily financial, resulting in only intermittent production.

In anticipation of future needs, Fitzsimmons undertook major improvements at the site, constructing new buildings, installation of a year round water system, renovations of existing housing, and excavation of cellars and an icehouse as well as clearing of adjacent lands for crops, gardens and horse pasture (Korvemaker 1973: 21).

Although Fitzsimmons was only moderately successful in his operations, he was forced to sell his company to L.R. Champion in 1943 and the company was renamed Oils Sands Limited. Production continued on an intermittent basis through 1944. In 1945, the Alberta Government announced that it would sponsor a separation plant in cooperation with Oils Sands Limited. Because of financial difficulties, this joint venture failed to materialize and the Bitumount plant and lease were taken over by the Alberta government in 1948. A new plant was completed the following year and the Alberta Research Council undertook experimentation in oil extraction. In spite of the production problems, the project was a success in terms of technical solutions to existing problems. By 1955, the Bitumount operation was sold to CanAmera Oil Sands Development Ltd. who granted Royalite Oil Company and option to sublease certain leases. The site of Bitumount passed to Royalite Oil Company on July 16, 1957 while B.S.L. 5 was retained by CanAmera. In 1958, operations at Bitumount were terminated (Korvemaker 1973: 38).

The site of Bitumount became a Designated Historic Resource on December 10, 1974. The surveyed site of Bitumount consists of 46.27 acres (Parcel A) with an associated access road (Parcel B) consisting of 1.25 acres in Section 1, Township 97, Range 11, West of the Fourth Meridian (Figure 6.5). Korvemaker (1973) provided the earliest historical documentation of the site for Historic Sites Service. In 1981, Nicks prepared a preliminary assessment of the industrial, archaeological, potential of Bitumount. Site mapping, feature inventory, and analysis was undertaken by Earthscape Consultants (1984) as part of the development proposal for Historic Sites Service (Figure 6.6). An additional report, supplementing the study, was prepared by Mr. Klaas Vink (1984) which detailed equipment and processes used at the site. Communication with Les Hurt, Deputy Director of Community Heritage Services indicates that the immediate objective at Bitumount is to ensure that the site remains undisturbed.

6.8 First Nation Concerns

The Chief and Council of the McKay First Nation have been contacted regarding any potential concerns that they may have with respect to archaeological sites or cultural properties and the design of the historical resource program. Specific cultural properties identified in the communication included trails, camps, medicinal plant collecting localities; spiritual, sacred, and burial sites. No response has been obtained to date directly from the band.

However, a report by Fort McKay Environmental Services Ltd. documents the band's concerns with respect to the Biophysical Resources Cumulative Effects Study Area (BCESA) (Fort McKay Environmental Services 1995). The report is based on interviews with local residents and a

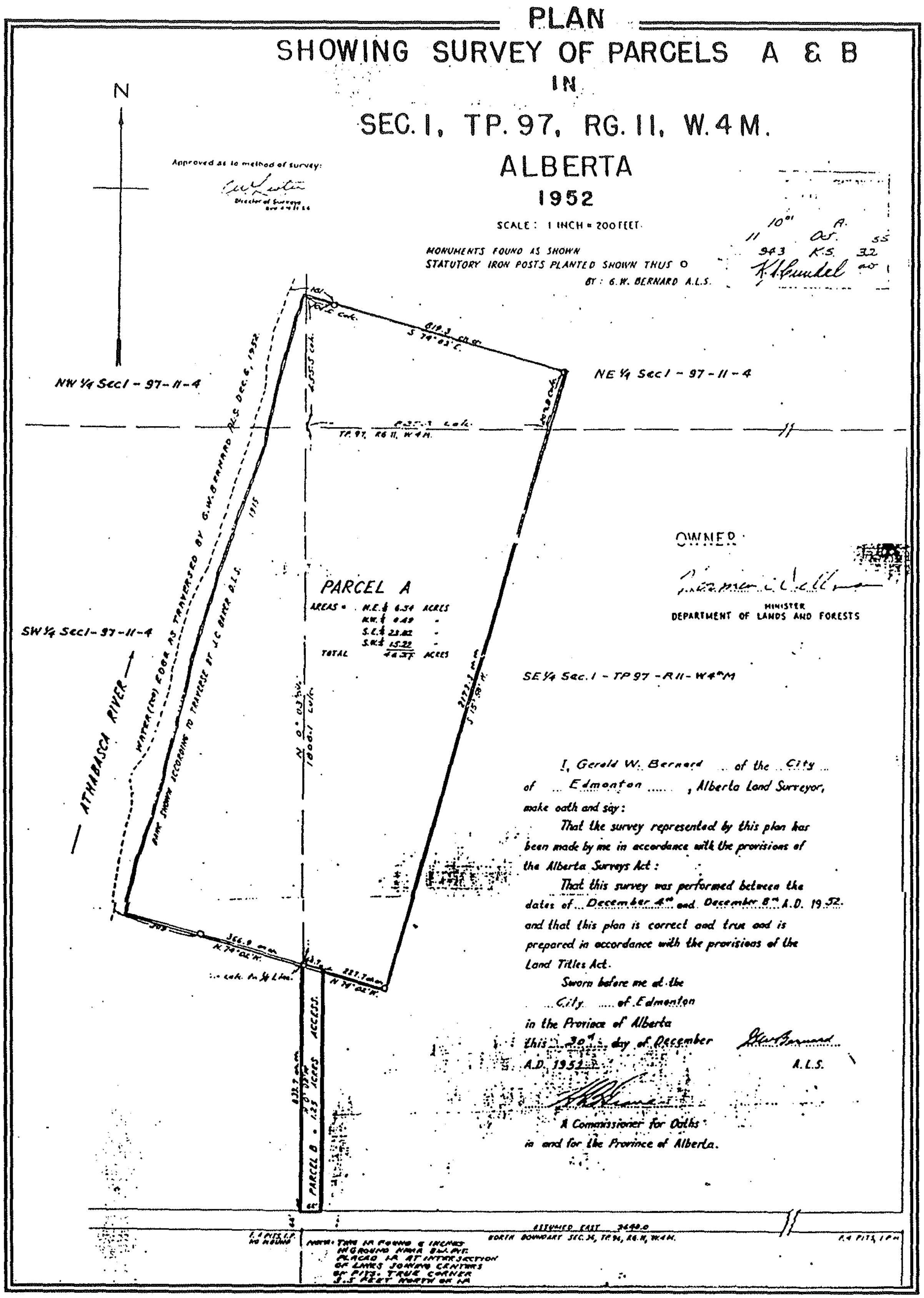


Figure 6.5 Survey plan of Bitumount by Gerald W. Bernard (1952).

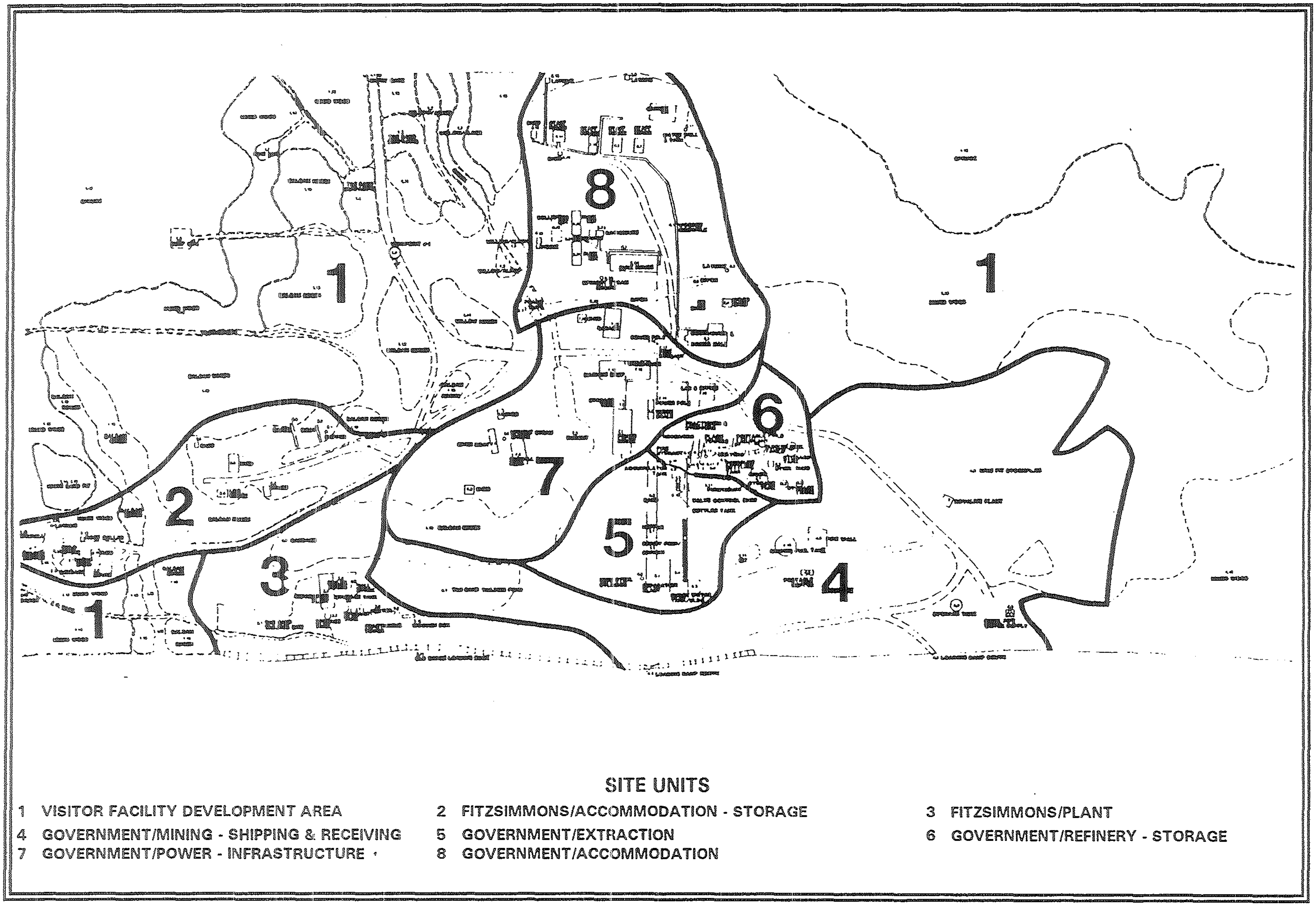


Figure 6.6 Inventory map of Bitumount (from Earthscape Consultants 1982).

publication of Traditional Knowledge entitled *There is Still Survival Out There.* A map accompanying the report provides information on traplines, cabins, historic sites, burials, and trails. In addition, the map documents locations of fur bearers, big game, game birds, fish, and various kinds of vegetation, including those of medicinal and spiritual value. Although the discussion relates to current traditional practices, species range/occurrence and nature and location of use can be extrapolated back to pre-white contact times. As such, the identity of the exploited species and their geographic range/location are important to models of prehistoric land use and hypothetical patterns of site situation for field investigation. This information is presented in Section 4.9 of this report.

7.0 HISTORICAL RESOURCES IMPACT ASSESSMENT

Activities associated with the Solv-Ex project that will affect historic resources are summarized in Figure 7.1.

7.1 Construction and Operations Impacts

Prehistoric, historic, and paleontological resource sites occur on the surface or beneath recent sedimentation, and may be altered, damaged, or destroyed by development projects which modify the landscape. From the perspective of historical resource disturbance, two types of developments associated with the Solv-Ex project have been identified for discussion:

- Project facilities/activities that disturb surficial historic resource sites including office and maintenance buildings and the construction camp (Figure 7.1); and

- Project facilities/activities that disturb deeply buried historic resource sites including forest clearing, mine excavation, tailings disposal and waste dump areas, processing and plant facilities, storage areas and tanks and utilities (including the site of water intake, water pipeline, potable and waste water reservoirs/ponds, gas pipelines, power lines, roads) (Figure 7.1).

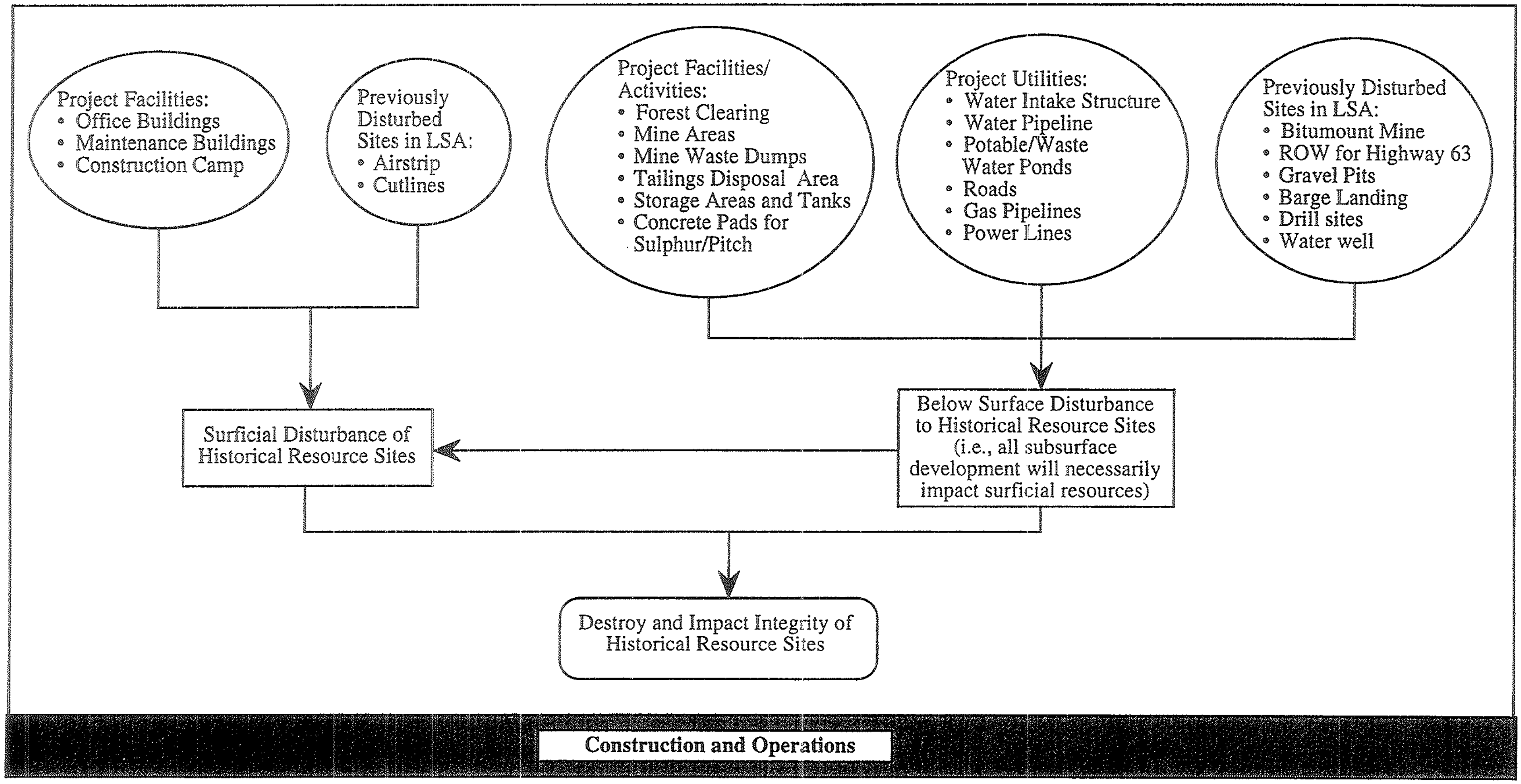
The impact on historical resource sites may be primary or secondary.

- Primary impacts are predictable, planned disturbance factors necessitated by the development of the project. Primary impacts of the Solv-Ex development on historical resources could include displacement and compaction of sites by vegetation clearing and landscape disturbance, coverage of sites by facilities, and loss of sites through excavations.

- Secondary impacts are unplanned disturbance factors such as increased access and unauthorized collection of artifacts.

Impacts are evaluated on the basis of known site densities and types of historic resources, and existing disturbance and proposed project facilities. Presently an Historic Resource Impact Assessment (HRIA) has not been conducted in the Local Study Area, so the types and locations of historic resource sites are not known. Some areas of the Local Study Area have been disturbed by previous development: Alberta Forest Service airstrip and water well, right-of-way for Highway 63, construction and excavation of Bitumount, gravel pits, cutlines and drill sites and the barge site.

Figure 7.1 **Previous activities in the Local Study Area, and proposed construction and operations activities and facilities associated with the Solv-Ex project will *impact or destroy the integrity of historical resource sites* in the Local Study Area. Effects can be divided into surficial disturbances and below the surface disturbances.**



An HRIA will be conducted for the areas to be disturbed by the Solv-Ex facilities (Lease 5 and utility corridor), under the guidance of the Provincial Museum of Alberta, Alberta Community Development and based on consultation with the First Nations. The HRIA will be scheduled for completion during August - September 1995, and will identify the location and describe historical resource sites in the proposed Development Area.

- Sites identified during the Highway 63 HRIA studies and the energy corridor studies, which are to be impacted by development of the proposed Solv-Ex utility corridor, will require evaluation in light of the proposed type of facilities to be constructed and facility-specific impact relative to the individual sites.

  - In the utility corridor, prehistoric sites of concern are the Cree Burn Lake Site (HhOv 16), the complex of sites identified as HhOv 3, HhOv 4 and HhOv 118, and sites HhOv 111, HhOv 113, HhOv 114 and HhOv 115. All early drill well sites within the corridor are of concern. Re-evaluation of each site relative to the facilities proposed for development in the corridor is required.

  - Based on UTM information, all of the 28 previously recorded sites in the energy corridor will be impacted by the proposed corridor development.

  - Within Lease 5, Bitumount is of primary concern. Avoidance, and consequently, no disturbance of the site area is required. Alberta Community Development has expressed concern that the boundaries of the site be clearly delineated in the field and that mechanisms be put in place to ensure that project facilities do not impinge on the site boundaries.

- The inventory of traditional land use practices and sites provided by Fort McKay Environment Services Ltd., identifies the trails and associated sites, materials, and markers, the cabins, and burial sites of specific concern. *Effort must be made to ensure that these sites are treated and maintained with the dignity and respect that they have earned and that they deserve. Desecration or damage to these sites will be regarded with disfavor* (Fort McKay Environment Services Ltd. 1995; Appendix V). In addition, localities at which exploitation of any specific natural resource occurred can be expected to be associated with cultural remains, for example, fish camps, kill sites, etc. Although not specifically identified in the report as being of concern, it should be noted that the location and content of these sites may be significant in the archaeological field study. Additional communication with the band (e.g., Elder interviews and site visits) will be made to acquire additional, more detailed information on the identified sites, and to ensure sites of significance and cultural properties are identified for avoidance. Intensive search will also be made for other historic sites such as trapping cabins, trails, and graves identified by First Nations.

- A field inventory for prehistoric sites will be conducted in Lease 5. The project area will be stratified on the basis of aerial photographs and vegetation and soils information. Each relatively isolated, terrain feature will be subjected to intensive, systematic, shovel testing and visual inspection of any existing exposures to enhance site discovery.

- Specific field search will be made to identify the location and remains of the early drill well sites.

- Relative to palaeontological materials, it has been pointed out that the Wabiskaw member of the Clearwater Formation holds good potential for fossil remains (B. Nichols, personnel communication, 1995). As such, it was recommended that concerted effort be made to note the presence of such remains during mining and report these finds to the Royal Tyrell Museum of Paleontology. Overburden removal personnel will be instructed to cease operations if they encounter any material that appears to be of historic value.

The significance of each site identified during the HRIA will be assessed from two perspectives: scientific and ethnic. Scientific significance will ultimately address the potential for determining chronological relationships, cultural relationships, social organization (i.e. group size and composition), activities enacted, technological variation, intersite relationships, and spatial and temporal variability of artifact forms. Ethnic significance will be assessed through consultation with First Nations.

Recommendations for final site dispensation of artifacts will be formulated with input from First Nations concerning ethnic significance, the perceived scientific significance, the magnitude of site-specific impacts expected to occur, and the site significance scheme developed. The objectives and strategies for operationalization of alternate mitigative measures will be sufficiently detailed to facilitate decision-making by project management. Historic sites that are deemed too small or sparse for full excavation or preservation, will be documented photographically, mapped and the artifacts collected. Those sites considered sufficiently important will be carefully excavated by test pits. Grave sites will be strictly avoided by all activities and personnel.

As noted above the Primary impacts to all Historical Resources associated with the Solv-Ex project occur due to vegetation clearing and land disturbance and excavation. It is anticipated that magnitude of impact will range from low to moderate, will be negative, long-term in duration, occur once and be irreversible. The scope of impact could occur at all three levels i.e., local, regional and provincial.

Secondary impacts, which could adversely affect historical resources, include the unauthorized collection of specimens by non-archaeologists, and unregulated vehicular activity. Such potential adverse secondary impacts will be managed by restricting access to the Solv-Ex site by unauthorized individuals.

Bitumount is a Designated Historical Resource at which future tourist development may occur. Given the proximity of the Solv-Ex development area to Bitumount, a visual negative impact may occur. It is anticipated that such impact will be irreversible and long-term and that residual impacts would accrue. Additional data is required in order to assess cumulative visual impact to the site of Bitumount.

Positive effects will accrue from the HRIA which will add to the database of the region and enhance our understanding of prehistoric and historic use of the region.

7.2 Cumulative Impacts on Historic Resources

The gross cumulative impact on historical resource sites is projected on the basis of the relative number of sites for which either impact was noted at the time of recording and/or at which subsequent development is known to have occurred to the total number of previously recorded sites in the Clearwater Lowland. The total number of previously recorded sites is 353; the total number of known sites to which impact has occurred is 223 indicating that over 60% of the total number of known sites in the Clearwater Lowlands have been impacted. Perhaps more significantly, over 70% of the known campsites, 70% of the recorded artifact scatters, 75% of the recorded quarries, and 73% of the recorded campsites/workshops have been impacted. Based on the nature of the proposed development, it is anticipated that relative potential for impact to historical resources will be high. Consequently, cumulative impact will continue to accrue.

7.3 Summary of Residual Impacts

The residual impacts of the Solv-Ex Experimental Co-production project on historical resources during the Life of the Project are summarized below. There will be no post-operation impacts on these resources.

Life of Operation:

- Historic sites will occur on, or very near surface. These sites will be identified through the HRIA of the Solv-Ex Development Area. Mitigative activities to minimize the Primary impacts to historic sites include formal documentation/descriptive photography, mapping, artifact collection and/or controlled excavation to retrieve pertinent data on the site and activities. Archival research and documentation may be required. Solv-Ex's management plan to minimize effects on paleontological remains will ensure that the Royal Tyrell Museum of Paleontology is contacted and monitors any significant finds. With these mitigation procedures in place, this impact is considered Low to Moderate in magnitude, will be Negative, Long-term in duration, occur Once and be Irreversible during the life of the project. The scope of impact could occur at all three levels of geographic extent i.e., local, regional and provincial due to the importance of historic resource information.

- Secondary impacts, which could adversely affect historical resources, include the unauthorized collection of specimens by non-archaeologists, and unregulated vehicular activity. Such potential adverse secondary impacts will be managed by restricting access to the Solv-Ex site by unauthorized indivudals. The impact should be Low in magnitude, Negative and Long-term in duration (other impact terms are not applicable).

- Bitumount is a provincially designated Historic Site. Solv-Ex development activities may visually impact the site, particularly in light of potential development of the site for tourism purposes. This impact is Negative, Moderate-term in duration and Irreversible during the life of the project (other impact terms are not applicable).

- Positive effects from the HRIA and mitigation activities to historic and prehistoric and monitoring of paleontological finds will contribute to the scientific database and understanding of the history and prehistory of the region. This impact is considered Long-term in duration (other impact terms are not applicable).

7.4 Monitoring

The management plan developed for Solv-Ex and associated contractors should: indicate that the Royal Tyrell Museum of Paleontology is contacted if paleontological sites are found during mining excavations and monitors any significant finds, and implement measures such as restricted access to the development site to minimize Secondary impacts to historic resources.

8.0 EXISTING SOCIO-ECONOMIC CONDITIONS

AGRA Earth & Environmental Limited (AEE), in cooperation with Foster Research, was retained to conduct a Socio-Economic Impact Assessment (SEIA) for the Solv-Ex Project.

8.1 Existing Conditions: Approach and Methods

The Alberta Energy Resources Conservation Board Guideline G-23 provides comprehensive specifications for content of the SEIA. To meet its requirements, we have adopted an issue-oriented approach for this assessment.

The issue-oriented approach to developing and assessing the project application, by its very nature, should be cooperative and lead to the proper identification, analysis and mediation of impact concerns rather than confrontation. The premise is that all key stakeholders in the project should participate in the identification and assessment of impact issues. The assessment team sought verification on the issues from the client, appropriate stakeholders (through brief consultation) and the regulatory agencies.

The approach taken was to provide baseline information on the socio-economic circumstances of the project and region, and assess the effects of the project on those circumstances. The process was an iterative one which began with simple quantitative, or statistical data collection and proceeded through issue identification and evaluation to the formation of impact hypotheses. These hypotheses were tested by stakeholder consultation before resulting in an impact conclusion, and where appropriate, formulation of mitigative recommendations.

In this section, the existing socio-economic conditions in the Fort McMurray, Fort McKay and Fort Chipewyan, as the primary impact communities, are reviewed. These communities and I.D. #18 amalgamated on April 1, 1995 to form the municipality of Wood Buffalo. For the purposes of this SEIA, impacts on individual communities are considered. This includes an overview of the historical development of the region and the existing condition of the study area's population, economy and labour, infrastructure and transportation, education, health and culture and law enforcement. It is not anticipated that other regional communities will be directly affected by the project due to its small size, short duration and experimental nature. Therefore, detailed information on other regional communities is not included. In Section 9, potential socio-economic impacts of the project are presented and impact mitigation strategies are outlined.

8.2 Regional Population

The historical background and existing population situation in the three communities that may be affected by the Solv-Ex Co-production Experimental Project are discussed. The primary study area communities are Fort McMurray and Fort McKay. The downstream community of Fort Chipewyan is also profiled. Fort McKay and Fort Chipewyan are Aboriginal communities while Fort McMurray has grown to become an important regional centre based on servicing the area's two massive Athabasca Oil Sands developments operated by Suncor and Syncrude.

Historical knowledge of an area's social, economic, cultural and political evolution and development is often essential to understanding current developments, and more particularly, the perceptions and reactions of people to new developments in an area. This is especially true in northeastern Alberta where the 18th and 19th century experiences of northern Aboriginals continue to influence the behavior and the judgments of their descendants. Similarly, the recent history of the area is relevant to understanding the present and the expected future behavior of resident non-Aboriginal people.

The communities in the study area share a common regional identity based on their traditional historical and cultural ties and participation in a common economic system. This regional identity has been weakened, however, by a segregation of the population into the individual communities of Fort Chipewyan, Fort McKay and Fort McMurray. These communities began as trading posts and church mission sites, but later became the focus of permanent settlement and government administration. The development of their collective regional identity has most recently been transformed by the swift rise of the oil sands industries and the accompanying influx of people from outside the region.

The trend to centralize government services stimulated a steady movement of people from the smaller communities to Fort McMurray. The social and economic dynamics of the study area have gradually altered as a dominant regional center has emerged, able to supply a broad range of goods and services. Relative to this growing center, the outlying settlements are experiencing only marginal development. The old informal infrastructure of bush and riverbank settlements has been gradually replaced by a modern network of roads and airports.

The primary sources of community population data used in this study are found in the 1989 municipal census for the City of Fort McMurray, the 1990 municipal census for Fort Chipewyan, the 1991 Canada Census and Aboriginal People's Survey (APS) and the 1995 Fort McKay First Nations estimate. As this (1992-1995) is an intercensal period, these identified sources represent the best available data pending the implementation of the next federal census in June, 1996 (data from that census would be made publicly available in mid-1997). The reader will note that all population projections presented here will be placed in the context of an assessment timeframe ending in the year 2006. This is to correspond to the nearest census year following the project activity period which will provide for ease of future monitoring and analysis and broad comparability with any other demographic projection studies/publications.

8.2.1 *Fort McMurray - Population*

Fort McMurray is located at the confluence of the Clearwater and Athabasca rivers, about 450 km northeast of Edmonton. It is the second oldest settlement in Alberta, having been occupied for almost 200 years. During most of this period it was a strategic link in the fur trade, and also important in the transportation of goods to and from settlements in northern Alberta and the Mackenzie River drainage area.

The most recent economic boom period began in 1973 when Syncrude received approval to construct an oil sands extraction plant north of Fort McMurray. While the earlier high growth periods would normally be followed by a decline, it now appears that, for the foreseeable future, Fort McMurray will maintain its size and position as the regional economic and government center in northeastern Alberta.

Each of the communities in the study area has its own distinctive characteristics while sharing a common set of influences in the past and the present. Changes in the economy of the area have provided the major impetus for change. These changes in the communities have had implications for the development of local infrastructure. When water routes, particularly the Athabasca River, were the primary means of travel, Fort Chipewyan was the transportation and trading centre of the region, and of much of the Canadian northwest. As new routes to the south were developed, first by steamboat and then by rail and road and air, Fort McMurray inevitably displaced Fort Chipewyan as the regional center.

In the 1991 census, the population of the City of Fort McMurray was determined to be 34 706 persons. The total population showed a 0.7% decrease from the 1986 census total of 34 949. The marginal decrease in the population of Fort McMurray has been suggested to be related to a decrease in the average family size from 3.22 to 3.07 people per household. This suggests those people who have been leaving Fort McMurray for the past few years may have had larger families than those who have been replacing them.

The results of the 1991 census show the City was, by comparison with Alberta as a whole, very youthful. About 90% (31 246 persons) of the total population were under the age of 45. This compares to an Alberta under - 45 average of 75%.

In fact, not only was a large percentage of the 1991 Fort McMurray population under the age of 45, but more than half (54%) of the total were between the ages of 20 and 44. This compares to an Alberta figure of about 44% for the same age cohorts. Given the type of heavy resource extractive industries upon which Fort McMurray is based, it is not surprising to see a preponderance of younger persons who generally are more attracted to, and capable of working in, such industries. The same rationale also explains the slight difference in the proportion of men and women in the 20 to 45 year old cohorts — men at about 54%, women at 46%.

Another feature of the demographic make-up of Fort McMurray in 1991, compared to Alberta, was the under-representation of those persons in the 65 years and older age cohorts. Alberta has about 8% of the overall provincial population in this bracket, compared to about 1% for Fort McMurray.

Ethnically, Fort McMurray has become a diverse, multicultural community. The size of the Aboriginal community is significant, with 1795 people making up about 5.2% of the population total in 1991 (note: the APS was conducted only in those communities which are predominantly Aboriginal). This is about the same number of people claiming French, Irish, Scottish and Canadian as their single ethnic origin. The dominant ethnic group is represented by the 7285 (21% of population) claiming English as their single ethnic origin. There are also large numbers of Germans, Chinese, Ukrainians and East Indians as well as "transplanted" Canadians from the Maritime Provinces and Ontario.

The demographic dynamics of a resource extraction and processing community such as Fort McMurray is usually dominated by large flows of in and out-migrants. This was evident in the

1991 census, where it shows 8615 people (25.4% of total population) had made a move within or into Fort McMurray in the past twelve months. Of these recent movers/migrants, 83.8% were from locations in Alberta, 14.7% were from other locations in Canada, and the remaining 1.5% were from other countries. Given the apparent youthfulness of these new migrants compared to those who have departed, it is not unreasonable to assume the family size per household may increase in the short-term as these new arrivals raise families.

8.2.2 *Fort McKay - Population*

Fort McKay is located on the west bank of the Athabasca River about 55 km downstream from Fort McMurray. The history of Fort McKay is similar to that of Fort Chipewyan in that early fur-trading posts provided the first occasion for non-Aboriginal settlement in the region. While exact dates are not known, trading posts were located in this area around 1815 and again in 1820. However, there were periods when no post was in operation. The rudiments of a settlement were in existence by 1912, and it was named Fort McKay in 1917. Early expectations that rapid community growth would accompany development of the oil sands did not materialize, but the community has grown slowly over the years.

Canada census, socio-economic and demographic data for Fort McKay were generally not available prior to the 1991 census year. Despite recent efforts to enumerate the populations of more isolated communities such as Fort McKay, there is a concern that Canada Census data are typically under-reported for northern and aboriginal communities.

According to census figures, in 1991 the community of Fort McKay had a population of 256 people. The Fort McKay municipal census was taken by I.D. #18 in March, 1995 and indicated a total community population of 332 people — an increase of some 30%. There appears to be a good case for exercising caution when comparing the gross statistical differences of those communities which have suspect enumeration results. In fact, there appears to be more support for the under-reporting case as personal communications with local community administrators in 1989 held that the population was about 350 persons (Syncrude SEIA 1992). In summary, the latter two figures are probably more accurate for total population and there appears to have been no major population increase in the community of Fort McKay in the 1989-1995 period.

While we will continue to use Canada Census data in this socio-economic evaluation, we also caution that there may be significant under-reporting for some variables. The latter is due to incomplete coverage but at a minimum the data would constitute a very significant sample and should be representative in percentage terms for most variables.

According to the 1991 census, the average family size was 3.7 people, higher than the 3.0 people per household in Fort McMurray. This is not a surprising result, as there is a long and strong tradition of the support for the extended or large family unit in many of Alberta's northern Aboriginal communities.

The 1991 census indicates that Fort McKay's population distribution approximates the provincial norms. About 78% (200 persons) of the total population were under the age of 45 — comparable to the provincial average of about 75%.

About 35% of the community population were between the ages of 20 and 44 (evenly split between males and females), a much lower average than the 54% shown for Fort McMurray. In fact, the other dominant age cohort in Fort McKay was youth under 15 years of age, which also represent some 35% of the population.

As was the case for Fort McMurray, the 1991 census shows a low percentage of persons in the 65 years and older cohort. Only 2% of the Fort McKay population is older than 65.

According to the data contained in the 1991 Aboriginal People's Study (APS), some 240 of the 256 residents, 93.7% of the population, reported having an Aboriginal heritage (includes Metis). There are no other significant minority ethnic groups in the community.

The demographic dynamics of Fort McKay appear to parallel those evident in other northern Aboriginal communities — moderate to high rates of natural increase, low rates of in-migration and low to moderate rates of out-migration. In 1991, the census shows that 50 people (19.6% of total population) had made a move within or into Fort McKay in the previous twelve months. All of the movers/migrants were from locations in Alberta (accounting for rounding errors). The 1991 APS also provides data on Aboriginal mobility. In this regard, 13% of Fort McKay Aboriginals indicated that they had moved within or into the community in the past twelve months.

8.2.3 *Fort Chipewyan - Population*

Fort Chipewyan is located on the Peace-Athabasca River Delta at the southwestern tip of Lake Athabasca, about 220 km north of Fort McMurray. Established in 1728 as a fur trading post, it is the oldest community in Alberta, initially serving as headquarters for trading activity to the frontiers north and west of the community. Missionaries soon followed the traders and, in time, established a school and hospital.

Today, Fort Chipewyan is considered to be an isolated community, lacking all-weather road connections to any other settlement. As a result, it has encountered few of the major changes which Fort McMurray experienced in the 1970s and 1980s. One link has been established and maintained in the past few years as Syncrude currently employs several community residents through a rotational fly-in, fly-out, employment program.

According to two of the 1991 Canada Census data sets obtained for this analysis, the community of Fort Chipewyan had a population of only 537 people. A third data set, compiled from the Aboriginal Peoples Study, provides for a total Aboriginal population of 860 in the community. Statistics Canada personnel have been contacted and are endeavoring to provide us with information concerning this discrepancy.

As noted in the previous section, prior to 1991, only consensus estimates of Fort Chipewyan's historical population were made available. Using the results of personal communications, Fort Chipewyan's 1989 population was estimated to be about 1500 persons (Syncrude SEIA 1992). Recent communication with the local administrator of the Municipality of Wood Buffalo (MWB combines and replaces administrations of the former I.D. #18 and the City of Fort McMurray) confirmed that the 1990 Fort Chipewyan municipal census totaled 908 residents. She added that the current local population was estimated at approximately 1200 to 1400 persons (Margaret Villebrun, pers. comm., 1995). While the current population estimate is lower than the 1989 estimate, we can assume that the local population has decreased slightly or remained stable over the 1989 - 1995 period.

As in the case of Fort McKay, there appears to be significant under-reporting of the Fort Chipewyan population in the 1991 Canada Census. As in the case of Fort McKay, we must rely on the census data for our analysis, but we again caution on the interpretation of gross totals.

According to the 1991 census, the average family size was about 3.9 people, comparable to the 3.7 people per family indicated in the other predominantly Aboriginal community in the study area, Fort McKay.

The census also indicates 81.5% of Fort Chipewyan's population were in the under 45 years old age group is slightly higher than the provincial average of about 75%.

The 1991 census shows that 35% of the population of Fort Chipewyan were between the ages of 20 and 44 (with nearly an even male/female split). This figure is also comparable to the 35% in a similar age cohort for Fort McKay.

The 1991 census indicates that 5.6% of the population of Fort Chipewyan were in the 65 years and older age cohort. This is significantly higher than the percentages indicated for Fort McMurray (1%) and Fort McKay (2%).

According to data from the 1991 APS, about 860 people in Fort Chipewyan claim Aboriginal heritage. There is some difficulty in determining the percentage of residents that are Aboriginal owing to the census data discrepancies identified earlier. However, based on other 1991 census data, a best estimate is that 75 to 85% of the community is Aboriginal. Similar to the Fort McKay case, there are no other significant minority ethnic groups in the community.

The population dynamics of Fort Chipewyan show that at the time of the 1991 census, about 23% of the population had made a move within or into the community in the previous twelve months. Of these movers/migrants, 92% had moved from locations in Alberta and the remaining 8% had migrated from other parts of Canada. The 1991 APS data set provides mobility data which shows that only 7.8% of Fort Chipewyan Aboriginals had moved within or into the community in the past twelve months. Perhaps this is not surprising, owing to the great difficulty residents would have of "getting out" of Fort Chipewyan (isolated northern location, poor and limited road access, recent cancellation of commercial air transport linkages, etc.)

8.3 Regional Economy and Labour Force

As with much of Northern Alberta, the study area economy is driven by activity in the primary industries. These industries include agriculture, mineral and hydrocarbon production, forestry, and commercial fishing and trapping. In 1991, 1510 (28.9%) out of an Improvement District (I.D.) #18 labour force of 5225 were in the primary sector. While agriculture is extremely important to the Alberta economy as a whole, both climatic and soil conditions inhibit its extensive development in the study region. There is no significant commercial agriculture in the study area.

While the forestry sector is expanding rapidly in other parts of Northern Alberta, the study area has not been the target of this growth to date. However, the Alberta-Pacific project near Athabasca/ Boyle has obtained a Forest Management Agreement which includes the Fort McMurray region and harvest and transport operations have commenced. Most of the land in the oil sands area was considered non-productive for forestry (Alsands 1979), but the use of aspen for pulp has changed the importance of the region for forestry.

Although fishing and trapping is a very significant activity in the study region, discussion here will be limited to its commercial aspects. Further discussion on its social and cultural significance is contained in the following sections.

The remaining economic activity in the region can be attributed to the following secondary and/or tertiary industries: manufacturing, construction, transportation, communication and utilities, trade, finance, insurance and real estate, community business and personal service, and public administration and defense. In 1991, the second largest employment sector in I.D. #18 was government services, employing 870 (16.6%) members of the labour force.

The services sector represents an important economic activity, in terms of labour force size, trailing only oil sands mining. It is perhaps worth pointing out that the "services" sector includes such activity as government, education and health and welfare services and thus reflects substantial governmental and quasi-governmental investment and expenditure. The private sector component involves accommodation and food services as well as other community, personal and business service industries.

As the subject of this application is the mining of oil sands and production of crude oil and other products, the technical information presented elsewhere in the Application should be referred to for a discussion of the regional resource base. Total Alberta production of synthetic crude oil in 1988 was 17.2 MMm^3 (including 6.7 MM m^3 of crude bitumen), worth approximately $2,203 million from a reserve base of 263.3 MM m^3 at the end of the year (Statistics Canada 26-213). Alberta government revenue from oil sands fees, rentals and royalties amounted to $310.3 million out of a total $5708.6 million in mineral resource revenues in fiscal years 1983-84 (Economic Development and Trade 1986). Most oil sands and synthetic crude production in Alberta originates in the study region.

The oil sands mining and processing industry dominates the regional economy and to a large extent its health and prosperity is a good predictor of that of the economy as a whole. Recent rationalizations of the operations of the two existing large operators have lead to "downsizings" and related community concerns about job security for both direct and indirect workers. The region has gone through a series of cycles of optimism and pessimism related to new large scale oil sands proposals such as Alsands, Canstar and OSLO which have failed to come to fruition. The current view looks relatively optimistic due to a recent production expansion approval for Syncrude, proposed mine expansions for both Syncrude and Suncor and experimental proposals such as Solv-Ex. A recent report of the National Task Force on Oil Sands Strategies sponsored by the Alberta Chamber of Resources paints a very optimistic future but a more realistic scenario would be the continued stable to slow growth scenario reflected in our population projections.

8.3.1 *Fort McMurray - Economy and Labour*

The 1991 Canada Census reports 7390 persons, or 37.0% out of a total labour force of 19 970 were employed in primary industries in Fort McMurray. The 1989 Fort McMurray municipal census identified 6950 persons (43.4%) as employed in 'mining'. This definition can be taken as synonymous with oil sands production and demonstrates the sector's overwhelming importance to the local economy.

The local business community is generally well-experienced with oil sands-related requirements, and will benefit significantly from the construction phase opportunities associated with the Solv-Ex Project. The 1989 Fort McMurray Industrial Directory indicates substantial capability with over 100 firms employing some 1600 people identified in the 'construction' category.

Statistics Canada reported that in 1986, there were 19 manufacturing establishments in Fort McMurray, which together, employed 199 persons, paid $4.8 million in wages and produced $18.9 million in shipments of manufactured goods (Statistics Canada 31-209). The 1991 Canada Census reports that 470 people (2.4%) were employed in manufacturing.

As is typical of much of northern Alberta, the construction industry in the project region, and Fort McMurray in particular, is highly susceptible to large variations in activity. These swings generally relate directly to the level of investment and production in the primary resource/oil sands sectors. The result is a highly dynamic industry with a highly mobile labour force. Measured in terms of contribution to the total labour force, the construction sector follows only oil sands mining and services in importance to the economy of Fort McMurray. In 1991, the census shows that 1580 people (7.9%) were employed in the construction industry.

Transportation and communications is another sector of economic activity which is relatively more important in northern Alberta than in the southern metropolitan areas. This importance has less to do with the sector's dollar or employment contribution to the economy than its strategic significance as the life-line of northern communities. Fort McMurray itself serves as the regional hub, and with respect to transportation, for example, generates activity in air, road, rail and water modes. About 5% of the Fort McMurray workforce was employed in the transport and communications sector in 1991.

Retail and wholesale trade is a sector of activity which is becoming increasingly important to the Canadian economy as a whole. Retail sales accounted for $348.6 million worth of activity, or $6,900 per capita in the City of Fort McMurray in 1988 (Canadian Markets, 1988/89). The 1991 Canada Census reported 2470 trade industry members (12.4%) in the Fort McMurray labour force.

Overall, the economic standard of living in Fort McMurray is high. In 1991, full-time workers made up about 86% of the labour force and unemployment was only 8.3%. With respect to personal income, Fort McMurray tax filers have incomes higher than the Alberta average by a margin of 35% to 40%. In 1991, the census showed that the average household income in Fort McMurray was $69,300.

8.3.2 *Fort McKay - Economy and Labour*

The community of Fort McKay has had a long association with the development of oil sands facilities in the region. Despite this fact, and the community's proximity to Fort McMurray and the existing oil sands plants, there is still a high local unemployment/ underemployment situation.

In 1991, the Canada Census reports that almost 50% of the labour force had been inactive in the previous 12 months with a participation rate was only 52.9%. The census reported an "official" 16.7% unemployment rate. No data indicating average household incomes was available.

In terms of sectoral employment, in 1991, 27.7% of Fort McKay workers were employed in the mining/oil industry and government services, respectively. About 10% of the labour force were employed in the education, forestry, construction and transportation industries.

While there is little commercial fishing in the study region and none in the vicinity of the Solv-Ex Project site, the area is surrounded by Registered Trapping Areas (RTAs). Trapping activity does not produce a large cash income potential, but since it would normally represent only one component of complementary land-based economic activities, which would include the harvesting of fish and hunting of game for food, the economic significance of these activities, together, can be substantial. The socio-cultural importance of these traditional pursuits by aboriginal people greatly enhances their total value.

On the basis of a need to better understand the local employment/training situation, Solv-Ex worked closely with the Fort McKay First Nation to develop and implement, a local employment needs survey.

The community of Fort McKay completed a "Current Labour Force" survey in April, 1995. A total of 202 local people were identified as "employable" and were asked to complete a survey. In total, 174 (86.1%) of Fort McKay's potentially employable workforce participated in the survey and the results are shown in Table 8.1.

The survey poses two questions regarding the current labour force situation in Fort McKay. First, what is your current employment status? Second, what type of employment would you prefer to be in the future?

The responses to the first question reveal the employment profile of the community of Fort McKay. Table 8.1 shows that the oil sands currently employ 26 full-time and 2 part-time people from Fort McKay, representing 16.1% of the current labour force. Only one resident indicated that they were currently unemployed in the oil sands sector. The second largest area of participation is in the construction/equipment operator sector, with 20 full-time and 8 part-time employees, also representing 16.1% of the Fort McKay labour force. This sector also shows a high unemployment rate, with 32 people out of work. The other economic sectors — clerical, retail sales and services — show unemployment rates of 50% or more. Clearly, the current workforce

Table 8.1 Fort McKay current labour force.

Employment Status	Full-Time Employment	Part-Time Employment	Unemployed	Desire Employment
Administration/Management	5	0	1	10
Education/Medical	7	0	0	12
Clerical	7	0	9	14
Retail Sales	4	0	5	6
Services	3	4	15	14
Hunt/Trap/Fish	0	5	0	5
Construction	16	7	27	24
Equipment Operators	4	1	5	8
Trucking/Transport	13	5	1	14
Oil Sands Operation	16	2	0	43
Oil Sands Maintenance	3	0	0	7
Oil Sands Equip Operators	7	0	1	14
Other	1	0	0	3
Total	86	24	64	174

Source: Fort McKay Current Labour Force Survey (1995) of Fort McKay is oriented towards participation in the oil sands, construction and transportation industries.

The question of employment "desires" is, obviously, a difficult element to assess consisting as it does of an individual's perception of their wants, needs, capabilities and ability to access the desired opportunity. The Fort McKay Current Labour Force Study examines this question. By adding across the columns, we are able to discuss the possible trends.

As Table 8.1 shows, although a total of 22 people indicated they were currently in the "services" sector (full-time + part-time + unemployed), only 14 people indicated their desire to have a future job in that area. The seasonal variability of construction employment also provides some insights into the Fort McKay labour force. For example, although a total of 50 residents are currently employed/unemployed in the construction sector, only 24 people indicated their preference for a construction job in the future.

The oil sands example is very graphic. There are currently a total of 29 oil sands workers living in Fort McKay, but 64 residents indicated that they would like to work in the oil sands in the future. Clearly, the prospect of steady employment and the high wage benefits of full-time oil sands work are attractive to many.

The Fort McKay employment survey showed that of the 202 residents identified as being "employable", 64 residents were currently unemployed — a 31% unemployment rate (much higher than the 16.7% indicated in the 1991 census). Of the 64 unemployed residents, only 5 qualified for UIC benefits and it was estimated that 15 adults were receiving Social Assistance.

The survey also identified 12 Fort McKay residents that were currently attending either university/technical, apprenticeship, computer or heavy equipment operator programs. Perhaps even more significant was the finding that 32 residents were presently studying towards their Grade 12 diploma or upgrading to G.E.D.

The community of Fort McKay, through its community-owned business ventures - the Fort McKay Group of Companies - will also seek active participation in the economic benefits of the project. In fact, they had completed a "Corporate Plan" in 1990 which discusses their corporate needs and objectives as well as general regional and oil sand-specific opportunities. This plan, produced with the OSLO Project in mind as the next likely oil sands construction opportunity, concluded that while they are concerned that high project wages may attract many of their key employees, they also identified the following potential construction and operations phase opportunities which they feel they have the capability to pursue:

- site and construction crew bussing;
- small parcel and mail expediting;
- materials hauling contracts;
- environmental monitoring and assessment;
- janitorial and camp maintenance;
- site and camp security;

- day labour services;
- heavy equipment contracting; and
- environmental clean-up and reclamation.

8.3.3 *Fort Chipewyan - Economy and Labour*

The community of Fort Chipewyan has only limited winter road access to the project area and has thus had only a peripheral association with the economic development of oil sands facilities in the region. The community also suffers from chronic unemployment/ underemployment problems.

In 1991, the census indicated that the largest economic sector in Fort Chipewyan was government services with 70 workers (35.9% of labour force). All other sectors had only minor inputs into the local economy.

The 1991 Canada Census reports that almost 75% of the labour force had been inactive in the previous 12 months and that the participation rate was only 58.0%. The community reported an "official" 27.9% unemployment rate. No data indicating average household incomes was available.

The community's Aboriginal organizations are active in promoting economic development. Both the Cree Band (Misikiew Economic Development Corporation) and the Chipewyan Band have economic development programs that facilitate and coordinate economic development opportunities. These organizations/programs represent important points of contact for the Solv-Ex project. The community currently supplies workers to existing oil sands operations on a fly in/out rotation.

8.4 Regional Infrastructure and Transport

The purpose of this section of the SEIA is to discuss the implications of the Solv-Ex Project for the major physical facilities/amenities which are necessary for any community to accommodate change. It will take an issue-oriented approach, addressing primarily those items which have been identified through stakeholder consultation as being of concern. For each of the study area communities, infrastructure will be addressed first, followed by a discussion of transportation conditions.

8.4.1 *Fort McMurray - Infrastructure and Transport*

The state of the housing market in Fort McMurray is currently characterized by substantial excess capacity, both in terms of developed land and vacant units. In total, Fort McMurray had 15 670 housing units in 1991, composed of 8110 single-detached homes, 965 duplex units, 1400 town houses, 3120 apartments and 2375 mobile homes. This distribution, by housing type, has remained virtually constant since 1982 (Canada Census 1991). The vacancy rate in 1989 varied from a low of 1.3% in mobile homes to a high of 21.5% in apartments, reflecting a recent trend of apartment dwellers taking advantage of the excess supply and resulting lower prices brought on by out-migration. Discussions with City planners reveal there is still substantial excess capacity in the local housing market.

In 1994, Fort McMurray had more than 75 000 m^2 of retail commercial space and more than 125 000 m^2 of service sector commercial space. The dominant segments of the retail space were food stores and automotive establishments, while professional services, hotels and food and beverage establishments had the largest portions of service sector capacity. In 1989, commercial space had a low 5% vacancy rate.

The industrial real estate market in Fort McMurray in 1989 reflected a 14% vacancy rate, representing 9813 m^2 of a total available 79 894 m^2. The largest categories of occupied space, by far, were the wholesale trade and durable goods manufacturing, followed by construction contracting. Total industrial land utilization was 313.9 ha (Concord Environmental Corporation and RMC Resource Management Consultants 1990).

Typically, when discussing community infrastructure requirements in support of population growth, there are two general types: one which responds more or less directly in proportion to population changes, and one involving demand for major capital investments which responds in stages or "thresholds" of growth. These components are the "big ticket" items that, due to economies of scale, must be provided in stepped increments of capacity, such as administrative buildings, public safety buildings and equipment (fire protection), major cultural and recreational facilities, and utilities (roads, water, sewerage, etc.). Due to their capital cost, these are also the items that generate the bulk of municipal debt.

As a result of Fort McMurray's previous experience as a high-growth resource community and the long-standing possibility that additional growth would be triggered by another oil sands project, the City has prepared itself well, in terms of major infrastructure, to accommodate this growth. All the categories mentioned above have been brought up to a capacity sufficient to accommodate a total city population of 48 000.

The regional transportation network consists mainly of an all-season, paved Highway 63 from the Edmonton-area to Fort McMurray. The highway is used extensively by residents and commercial concerns to transport goods from the south. North of Fort McMurray, the highway also serves two other primary purposes: first, as the link between the residential communities of Fort McMurray and the Suncor and Syncrude Oil Sands Plants, and second, as the major economic and social conduit between the communities of Fort McMurray and Fort McKay. Alberta Transport estimates AADT flows between Fort McMurray and Fort McKay to be 185 vehicles per day.

Fort McMurray has an asphalt paved airstrip and a recently built, modern, air terminal facility. Daily commercial air jet service to Edmonton and other points is provided from Fort McMurray.

8.4.2 *Fort McKay - Infrastructure and Transportation*

The community infrastructure in Fort McKay consists of a school, nursing/medical station, store and tribal office facilities. These facilities are adequate for the existing population base.

Highway 63 is the key transport linkage between Fort McKay and the Suncor and Syncrude Oil Sands Plants, and second, as the major economic and social conduit between the communities of Fort McMurray and Fort McKay. North of Fort McKay, Highway 63 becomes the winter road to Fort Chipewyan. Alberta Transport estimates AADT flows between Fort McMurray and Fort McKay to be 185 vehicles per day. The equivalent traffic flows north of Fort McKay are reported to be 80 vehicles per day.

8.4.3 *Fort Chipewyan - Infrastructure and Transport*

Community infrastructure in Fort Chipewyan consists of 2 schools, a hospital, several stores and government offices. These facilities are adequate for the existing population base. South of Fort Chipewyan, Highway 63 becomes the winter road to Fort McKay. Fort Chipewyan has an asphalt paved airstrip. The community has one day per week commercial air service to Hay River.

8.5 Regional Education

This section contains a discussion of the existing resources and conditions in the study area with respect to education facilities and courses. Education, particularly its quality and appropriateness to meet Aboriginal needs, has been of increasing concern in recent years to northern Aboriginal communities.

An Aboriginal Issues Committee (AIC) was formed as a result of the OSLO Application Review Team Process in 1990. It had representatives of all regional aboriginal communities and interest groups, provincial and federal government officials, with aboriginal and human or natural resource development mandates, regional educational institutions and major regional employers. In addition to specific recommendations, a few central, common themes emerged with specific relevance to education:

- the need for more community-based programs;
- the need for input into, and control of, education programs by aboriginal people;
- an emerging trend towards local educational autonomy as a future goal;
- the need to better define educational "success" and related need for a positive feedback system for attainment of success;
- more communication between the communities and education institutions and their Boards/management; this communication to include feedback on the effectiveness of the programs and more information on educational and employment opportunities.

A specific recommendation, of the AIC was to network with industry and training institutes to focus on current and relevant employment and training issues to facilitate direct employer/industry contact with schools with respect to career opportunities of aboriginal peoples.

8.5.1 *Fort McMurray - Education*

The Fort McMurray Public School Board operates a two-tier system, with 12 schools offering Early Childhood Services (E.C.S.) to Grade 12. While most cities of its size would normally operate a three-tier system, (E.C.S. to Grade 6, Grades 7 to 9, Grades 10 to 12), the fact the community is so spread out means that utilizing the current approach enables children to stay in their own neighbourhood longer. It is felt that this makes the school a better focus for community activity and limits the amount of bussing.

In May of 1995 the system had an enrollment of about 4900 students and was operating at about 75% of net capacity. The Superintendent estimated that there was an excess of spare capacity. The system will close 3 elementary schools at the end of this school year and consolidate programs in existing schools (John Waddell, pers. comm.).

The Catholic School Board also operates on a two-tier system with eight schools; some elementary schools offer ECS to Grade 6, others offer ECS to Grade 9 and there is one senior high school (Grades 10-12).

The Board completed construction of a new elementary school in 1993 (ECS - Grade 6) in the Dickensfield area, with a capacity of approximately 375 students. The spare capacity is not evenly distributed and future student population growth could exacerbate this problem, depending on where it is expressed geographically.

Keyano College has been catering to the advanced education needs of northeastern Alberta for 25 years. For the first ten years, it was known as the Alberta Vocational Centre, Fort McMurray, providing academic upgrading and employment training to the area labour force. The advent of Suncor and Syncrude plant construction and operations gave the College its initial focus. In 1975, the AVC was re-designated as a regional provincial college and named Keyano College. The mandate was broadened at that time to include general education programs as well as the more specialized programs leading to technical and career occupations.

Keyano College now operates out of three campuses — Clearwater, Mackenzie and Fort Chipewyan. The Clearwater campus, in downtown Fort McMurray, houses academic, career, continuing education, trades, nursing, technology and visual performing arts programs. The Mackenzie campus, located in the Gregoire Industrial Park, is the facility dedicated to the heavy industrial training programs. Fort Chipewyan campus offers a variety of programs specific to the communities' needs.

The total number of students enrolled at Keyano College over the past five years has grown slightly from 1047 in 1989/90 to 1183 in 1994/95.

Keyano provides province-wide delivery of heavy equipment operation and truck driver training. This activity includes oil sands industry-specific training provided by Keyano. Courses include automotive electronics, rigging, blueprint reading, organizational behavior, programmable logic control and process operations.

8.5.2 *Fort McKay - Education*

Education programming in Fort McKay involves a number of different agencies in addition to the Band Administration and the Northlands School Division Number 61, under the auspices of which the Fort McKay School operates. The Athabasca Tribal Corporation operates Occupational Skills Training and post secondary and secondary education support programs. Keyano College has offered truck transport training and bus driver training programs and as recently accessed funding to provide a full-time educational upgrade instruction in the community.

The Fort McKay School provides basic educational services through the implementation of programs ranging from play school through E.C.S. to Grade 9. High school students are bussed, daily, to schools in Fort McMurray. Enrollment in the Fort McKay School has been very stable over the past 5 years.

The Fort McKay Band produced an Employment Training Needs Assessment and Plan (Aboriginal Employment Transitional Service 1990) which produced findings that also impinged upon the area of education. The findings of this study indicate that successful education programs in Fort McKay are typically those which were offered in a classroom-format and are directly relevant to community needs.

Recommendations of this study include the provision of "essential services" such as day care facilities and transportation to better enable and support Fort McKay residents to further their education. In addition, it was recommended that the community request greater aboriginal participation in the area of support services at both the Fort McMurray High School and Keyano College. It was felt that the provision of counselors could decrease drop-out rates and increase attainment. It was further recommended that the community adopt a number of measures to demonstrate positive support for those individuals who do choose to further their education, and importantly, recommended the Band establish a minimum educational attainment requirement of Grade 12 for positions in the Band administration and Band companies.

8.5.3 *Fort Chipewyan - Education*

Fort Chipewyan is also a part of the Northlands School District Number 61 and has a full program of Early Childhood Services through to Grade 12. According to available data, the schools in Fort Chipewyan are operating significantly below their capacity.

8.6 Regional Health and Culture

This section deals with existing conditions in respect to culture, community and families in the Solv-Ex Project study area. Separate discussions are provided for each of the three study area communities: Fort McMurray, because it is the regional center, providing the probable place of residence for some of the construction work force and most of the Solv-Ex operational work force; Fort McKay, because it is situated close to the Solv-Ex lease and plant site, is potentially most strongly affected by changes in operations; and Fort Chipewyan, a community downstream of the proposed oil sands project.

Fort McMurray is considered first, with discussions of current conditions, resources and prospects which relate to culture, community/family health, physical/mental health and substance abuse conditions. These same aspects are then considered in the Fort McKay and Fort Chipewyan contexts.

8.6.1 *Fort McMurray - Health and Culture*

8.6.1.1 Fort McMurray - Socio-Cultural Circumstances

Socio-cultural issues in Alberta's Aboriginal communities relate to contradictions and accommodations between the traditional Aboriginal culture and contemporary Canadian culture. These are real issues for Aboriginal residents of Fort McMurray, of course, but by choosing to leave their home communities (Reserve, Metis settlement or Aboriginal community) and to settle in Fort McMurray they have chosen to live in a Canadian cultural context.

In Fort McMurray, cultural issues relate to community life in a multicultural society. This has been a multicultural community throughout its 125 or so years of existence. The Aboriginal/Canadian cultural mix saw an early shift from northern Aboriginal to Prairie Canadian cultural preeminence. With the development of the Suncor and Syncrude projects, the cultural mix became more diversified with the arrival of Maritimers and French Canadians. New Canadians of Asian origin are the most recent arrivals. However, all have tended to become increasingly well integrated into the community.

As each grouping reached a "critical mass" it has established its own distinctive clubs, associations and religious organizations. "Generally the attitudes of the numerically dominant Anglo-Canadians toward these groups has been tolerant, though the existence of some underlying hostile or defensive feelings is reflected in derogatory humor." (Concord Environmental Corporation and RMC Resource Management Consultants 1990). Parents report that some Aboriginal children have experienced negative comment from classmates in school. The police report no recent incidents of clearly interracial or interethnic conflict in the community, as of May, 1995 (Inspector Colson, pers. comm.).

The most important agency promoting positive relationships between the various ethnic groupings in Fort McMurray is the Multicultural Association of Fort McMurray. A multicultural educational program is delivered by the single paid staff person, working with volunteer assistants, through school presentations, guest lectures, and ethnic entertainment and food events. The Heritage Days celebration is the most important annual event and appreciation of different ethnic cultures is becoming more widespread in Fort McMurray.

8.6.1.2 Fort McMurray - Community and Family Health

Because Fort McMurray grew from just a hamlet to become a small city in less than 20 years, most residents had little or no feelings of identification with the community as recently as ten years ago. While relevant survey data are lacking, there are indications that many are now proud of the facilities and programs that the city affords. Others are dissatisfied, especially with the isolation and the harsh winters.

It seems clear to all that the community, which was somewhat raw and "unfinished" at the beginning of the 1980s, has now "come of age". This is perhaps most apparent in the very broad range of facilities and programs now available, but it is also seen in the increased stability of the population, and the decline in "boom town" drinking patterns, for example.

Particularly noteworthy is the energy and enthusiasm of the populace. Fort McMurray has a distinctively young population and this may help to account for the willingness with which people have contributed their labour and time to neighborhood projects and children's programs and helping to integrate newcomers through the Family Support Volunteer Program. Perhaps the most impressive indication is the fact that per capita donations by Fort McMurray residents to the United Way fund drive have been the highest in Canada, for a number of years (John Waddell, United Way Chairman, pers. comm.).

There are indications that the level of optimism in the population is no longer as high as it once was. In the past, although complaints about the community were not uncommon, there was a general feeling of confidence that employment was secure, that people did not have to worry about employment, and that Fort McMurray would continue to grow. This is no longer the case, for a number of reasons. In the past, no less than three carefully documented proposals for new oil sands plants, Alsands, Canstar and OSLO, have all failed to materialize. The prolonged recession of the Alberta and the national economies has also had a dampening effect. That the community lost more than 10% of its population between 1985 and 1989 further strengthens these feelings of insecurity, and perhaps make people more cautious. However, along with the Solv-Ex Project proposal, both Suncor and Syncrude are now in the process of examining new production and development scenarios.

The Human Services Needs Assessment Study (Price Waterhouse and Peter Faid 1991) has called attention to salient aspects of Fort McMurray families. In comparison with the Alberta population, these families are young, with one third of all adults aged 30 to 44 years and half aged 20 to 44, in contrast to the provincial figure of 44%. Thus, many families have young children, and in over 40% of families with children under five years of age, both parents are employed, one full time and the other full or part time. In fact, in 28% of such families both parents work full time (Waterhouse and Faid 1991, p 8).

The incidence of babies born to single mothers in the Fort McMurray Hospital is higher than in the province as a whole. In 1983, 20% of all births were to single mothers, and this figure had increased to 30% by 1988, when the all Alberta figure was 17%. Among single parents caring for live-at-home children, two thirds are employed full or part time.

The recency with which Fort McMurray has grown has several important consequences for families. There are few long term residents, and even as recently as 1991, some 20% of the population had arrived during the preceding 12 months, an increase over the 8.1% for 1986. As a result, substantial numbers are newcomers who have left parents, extended families and friends behind. In particular, the almost universal lack of local extended families is a characteristic social workers often point to in explaining family problems.

It is apparent that in contrast to families elsewhere in Alberta, the "mix" of families in Fort McMurray and the situation in which they find themselves is quite distinctive. A higher proportion here than elsewhere are young couples, perhaps both are employed at an oil sands plant, work long hours during their work days and have unusually high incomes. As a result, during their days off some of them feel they "owe themselves a good time" and so they tend to indulge themselves rather than being with their children. These children do need this time because one or both parents may be away 13 or 14 hours a day on work days. The combination of poor communication, poor parenting, too much money and too much unsupervised time, results in some of these children getting into trouble with alcohol or drugs or petty crime.

The elevated incidence of families having many of the characteristics just described explains a characteristic paradox in people's descriptions of Fort McMurray. On the one hand it is described as a good community in which to raise a family: it is not dangerous, it is well equipped with playground, park and recreational facilities; there are many children around for one's own to play with, and there are many good programs for children. On the other hand, however, there is a great deal of concern about the welfare of children and adolescents in the community.

Given the long work days that many parents put in at the plants, before and after school care is necessary for many grade school children. Such care is provided by the YMCA at the Thickwood and downtown locations for children, aged 6 to 12 years. However, because of the inaccessibility and the expense of these programs, many children are said to be "latch key" children, who provide their own breakfasts because their parents have already left for work, and return home from school well before their parents.

The most worrisome aspect of family life in Fort McMurray today relates to the effects of increased levels of stress and insecurity among many people in the community. Increased insecurity has many causes — the termination of long-term oil sands employees and the fact that with smaller plant payrolls there is reduced volume of business in the community. Add to this the prolonged recessions in the Alberta and the national economies

Inevitably, the pressures and insecurities just described will impact on family life, and many in the helping professions in Fort McMurray report that this is the case. As a result of contacts with workers and with their spouses, they report increases in alcohol abuse, and a resulting definite increase in family violence.

8.6.1.3 Fort McMurray - Recreation

This section documents the existing resources and conditions in Fort McMurray with respect to recreation and culture facilities and services. Activity in this sector in Fort McMurray is organized under the direction of the City of Fort McMurray Recreation and Culture Division. The Division delivers services which include information/referral, programming (including facility allocation/management), volunteer development, grant consultation/administration and community development.

Recreation and Culture in Fort McMurray operates on a decentralized model. While the Division develops programs and manages facilities, it does so in response to community-based initiatives, and where possible, encourages and supports community-based groups in meeting their own programming needs. There are over 200 such groups in Fort McMurray, largely organized along functional/interest lines rather than by sub-community. This philosophy is consistent with a community development approach and is predicated on providing professional/technical resources in support of community-identified needs and priorities on the reasonable assumption that those who are best equipped to initiate and administer much of the programming are the users themselves.

The operation of the Division is assisted by a Community Services Advisory Board (CSAB) and a Recreation and Culture Sub-Committee. These bodies advise both City Council and the Division administration and act in a liaison role with community groups and the public-at-large. Members of the CSAB are appointed by City Council.

The major facilities managed by the Division include three indoor/skating arenas (Thickwood, Beaconhill and the C.A. Knight Recreation Centre), the Centennial Pool and 45 outdoor sports fields. In addition, the City has also taken over operation of the local ski hill. Utilization information indicates the arenas were operating at 80 to 90% of capacity, measured in hours used versus hours available, during prime hours, and have an overall utilization rate of 70 to 75%.

The YMCA opened a new pool facility (in a building shared with Westwood High School) in the fall of 1987. The Y facility also includes a children's wading pool, sauna, steam room and whirlpool, three racquet sports courts, a weight/exercise room, members' lounge and day care centre. The community pool capacity has been under-utilized in recent years.

In addition to City parks and trails, the Fort McMurray region's outdoor recreation resources include Gregoire Lake Provincial Park. The Park, which offers both camping (140 sites) and day-use facilities, is located about 30 km south of Fort McMurray. It has recently undergone an upgrading of its facilities, including the campground, day-use areas, the trail system and beach.

As might be expected, the pattern of usage shows that utilization peaks during the summer months and is much higher on weekends than weekdays. July is the highest usage month followed by June and August. This is true both of camping and day-use but a slightly greater percentage of camping use is typical for weekends than day-use.

The cultural resources in Fort McMurray that are a concern are those amenities, opportunities and programs which improve the quality of life and include the library, media, lecture, dramatic and musical facilities and other events which the City of Fort McMurray is now able to offer. In all these respects, the City is well supplied. The library is a new facility with a collection of 59 000 bound and paperback volumes.

The City is well served with media facilities, having a newspaper (published 5 times weekly), the two regional daily papers (the Edmonton Journal and Sun), three radio stations and 27 television stations available by cable, together with some cable-delivered community programming.

The largest auditorium in the city, the Keyano College Theatre, has a capacity of 600 persons. In addition, the MacDonald Island Recreation Complex curling rink is used as a open space area for such events as "Oktoberfest" celebrations in summer, when its capacity is 1700 people. A varied program of events is scheduled during the course of the year at the Keyano College Theatre. There is currently considerable unused capacity at community cultural events, but where this is not the case, additional capacity can be created by scheduling extra performances.

In addition to the library and the Keyano College Theatre, cultural facilities include access to meeting, crafts and multi-purpose rooms in several schools, the Family Y, the Oil Sands Interpretive Centre, Snye Park, the Thickwood Heights Community Centre, the Nistowayou Friendship Centre, Heritage Park, MacDonald Island, the Northward Leisure Centre and the Gregoire Park Recreation Centre.

Despite the relative isolation of Fort McMurray, the city appears well provided with cultural resources.

8.6.1.4 Fort McMurray - Physical Health

The majority of physical health care facilities available in the study area are located in Fort McMurray, and are designed to serve the needs of people living in the city and in the outlying communities as well.

Physical health needs of people in Fort McMurray and northeast Alberta are primarily served by the recently formed Northern Lights Regional Health Authority which includes the Fort McMurray Region General Hospital, the Fort McMurray and Region Health Unit and emergency medical service units. The hospital facilities may be described as unusually adequate to the needs of the region at this time, for three reasons.

- The Fort McMurray Region General Hospital was initially over built and the 150 bed facility operated without use of the fifth (top) floor for several years. This floor remained undeveloped until April 1992 when approval was received to convert it to a 30 bed long term care unit.

- The existing hospital facility was developed to accommodate demands projected during the early 1980s at a time when the population of Fort McMurray was expected to grow more rapidly than it has. Thus, it has the capacity to easily accommodate current and projected demands.

- The length of a patient's hospital stay has tended to decline, and continues to decline, as a result of reduced fertility in the region, new surgical and medical techniques, and medical cost-reduction pressures. Thus, the current facilities are expected to continue to be adequate, even if the population of the region continues to grow, as a result of net natural increase.

The second major resource for dealing with health conditions in the area is the Fort McMurray and District Health Unit. The Unit provides a wide range of services, including pre-natal and post-natal services for mothers, delivery of a range of health services to Aboriginal communities in the area, public health inspections of restaurants, screening and testing for sexually transmitted diseases and delivery of a pregnancy and family planning program for teens and adults.

Emergency medical services are provided by the Fort McMurray Ambulance Service administered by the Fort McMurray Fire Department, with assistance from the Suncor and Syncrude medical units, which provide accident treatment and nursing services at the plant sites. These three parties have signed an effective "Mutual Assistance Agreement". This agreement provides that each unit will respond immediately to highway accidents occurring closest to its own home base, and that all will respond whenever there is a medical emergency of sufficient severity to require such pooling of resources. The three parties to the Mutual Assistance Agreement have ambulances with life support facilities, full or part-time nurses, paramedics and firemen with emergency medical training.

Over the past several years, the hospitalization patient day rates per 1000 population, for all categories of care, with the exception of obstetrical and pediatric care, are lower for the Fort McMurray Hospital, than the rates for all Alberta hospitals. The main reason is that the Fort McMurray population is significantly younger than the Alberta population.

Information is available on the incidence of sexually transmitted diseases in Fort McMurray Region (served by the Regional Hospital and Health Unit) and in Alberta for selected years between 1976 and 1991. The data show that as recently as 1986, when the rate was 20.6 per 1000 population aged 15 and over for Fort McMurray, the rates for the city were often more than twice as high as those for all of Alberta. Since 1986, however, the Fort McMurray rate fell dramatically, so that by 1991 it was only slightly higher than the Alberta rate, 6.8 and 6.1 per 1000 population, respectively.

Discussions with the local health unit indicate that the rate of STDs since 1991 has remained constant. This is attributed to additional counseling in prevention and education (Ellen McGladdery, Fort McMurray Community Health Nurse, pers. comm.).

8.6.1.5 Fort McMurray - Mental Health

Mental health conditions often overlap with physical health conditions: people with mental disorders may present physical symptoms which require treatment. However, most of those suffering from mental or emotional disorders do not evidence obvious physical symptoms, and those with less severe conditions may work out their difficulties without professional assistance.

This section presents a brief discussion of the range of mental health problems experienced by people in the study area, as reflected in the available data. The varied problems include adjustment and relationship problems, acute reactions to stress, depression, child maltreatment syndrome, post-traumatic stress disorders and occasional more severe conditions like paranoia and schizophrenia. Since data on the incidence of these conditions is based on tabulations of those seeking professional help with their problems, "hard data" obviously underestimates the incidence of these problems in a community. They should be viewed as indices, which may reflect changing rates of such problems in a community undergoing change.

It is for this reason that it has been necessary to depend in part on "soft data" in the form of the informal observations and judgments of those helping professionals who have spent a number of years in Fort McMurray, and so have a sound basis for their evaluations.

Virtually all of the local mental health resources in the study area are found in Fort McMurray. Since some 90% of the study area residents live there, these people have the advantage of ease of access, but the transportation facilities in the outlying communities converge on this city, facilitating access for residents of these communities.

In terms of the resources formally available, Fort McMurray is well equipped with a broad range of helping facilities and services.

There are many non-professional assistance programs offering such help by trained lay-people include Peer Counselors of the Family Volunteer Support Program, the Women's Resource Centre, the Victim's Service Organization, Growing with Grief, the Help Lines of Some Other Solutions Society (suicide prevention), the Sexual Assault Centre, and Alcoholics Anonymous, together with its auxiliary groups of wives and teens.

The Fort McMurray Chapter of the Canadian Mental Health Association does not provide therapy or counseling. However, the Director and the Volunteer Co-ordinator, assisted by many volunteers, work to promote mental health in the community by monitoring treatment of the mentally ill, and providing advocacy for patients who may have been ill-treated.

The nature of the Fort McMurray community gives grounds for expecting both that mental health conditions will be better, and that they will be worse than the provincial average. Good conditions are indicated by the facts that the population is young and has the resilience of youth, is community-concerned and is dependably employed at well-paying positions. On the other hand, there are numbers of opposing influences. Perhaps the most significant is the fact that very few of the non-Aboriginal Fort McMurray residents have extended family members in the community, so they lack the support that relatives often provide. This vulnerability is exacerbated by the fact that higher-than-average proportions of the population are young and inexperienced, have poor parenting skills, and are prone to over-spend their sizable incomes.

Most of the knowledgeable informants with whom mental health conditions in Fort McMurray were discussed were explicitly of the opinion that the long work days, and the 28 day shift cycle that is employed at the plants, added significantly to the stress experienced by the affected workers and their families. The over-tiredness from working 12 hour shifts, the dislocations from changing from day to night shift and back again, the difficulties in getting enough sleep when on night shift, the many days when there was little if any time to relate to other family members, were all identified as stress-inducing for the worker, his/her spouse and children, if any. These mental health professionals acknowledged that there appeared to be little dissatisfaction with these arrangements among affected workers, and indeed that most appeared to like the arrangement.

8.6.1.6 Fort McMurray - Income Support

Income support refers to the condition of people in need of Social Assistance payments when other sources of financial support are unavailable or not adequate. This may be the result of unemployment, or of physical or mental illness affecting the employability of either the person him/herself or his/her primary source of support, for short periods, or permanently.

An increase in income support requirements may result from large development projects when an influx of people attracted by a project to an area of limited facilities results in local inflation of living costs, rents, utilities, services, food, etc. Fort McMurray is probably sufficiently large and sufficiently well equipped (and in some areas, over built) that there should be no more than modest local inflation. Income supplementation is the responsibility of the Provincial Department of Social Services. In the study area, Department offices are found only in Fort McMurray.

Income support rates in Fort McMurray tend to be significantly lower than in other parts of Alberta because of its distinctive population. The proportion of young workers, in their prime working years, is very high, and there are very few "seniors" who are vulnerable to dependency because their fixed incomes are eroded by inflation. Moreover, there are elevated proportions of professional and highly skilled workers in the city, and family income levels are commonly high. Finally, since many in the population have arrived within the past one or two decades, those who lose their jobs, retire or become handicapped, often return to their prior home communities. All of these trends reduce conditions of income support in Fort McMurray.

8.6.1.7 Fort McMurray - Substance Abuse

"Substance abuse refers to three different patterns of behavior: excessive use of alcohol, consumption of which is of course generally legal; consumption of other, non-prescription "mood changing" drugs (marijuana, hashish, cocaine, heroin, "angel dust" and other more exotic drugs) which is not legal; and excessive use of prescription drugs, primarily tranquilizers." (Concord Environmental Corporation and RMC Resource Management Consultants 1990).

In the following discussion, the term "resources" refers to both statutory and non-statutory facilities and programs for dealing with substance abuse problems.

As is true of many communities in North America generally, substance abuse is a significant problem in the study area. The elevated proportions of young people and Aboriginal people in this area, in comparison with the rest of the province, of course means that unusually high rates of substance abuse may be expected, since these components of the population are often at risk of increased abuse.

Fort McMurray has as impressive a set of resources for dealing with substance abuse problems as any small city in the province. This level of resources is necessary, however, because the Fort McMurray resources serve the needs of all residents of northeast Alberta, because of the isolation of this area from other locations where services and facilities are found, as well as because the population is at elevated risk because of its distinctive composition and economic situation.

The major resources for dealing with substance abuse problems include facilities at the Fort McMurray Region General Hospital for treating patients who have over-dosed on drugs, the Pastew Place Detox Centre, the Alberta Alcohol and Drug Abuse Commission Area Office, and most recently, the Mark Amy Treatment Centre. As well, there are chapters of Alcoholics Anonymous (AA), Alanon (the AA organization for spouses of alcoholics) Alateens (the AA organization for children of Alcoholics), and Partners, an organization for dealing with the alcohol and drug abuse problems of adolescents.

The most specialized service is provided by the Alberta Alcohol and Drug Abuse Commission Area Office. Individual and family counseling are provided, together with group work, and providing assessments, referrals and alcohol education in local schools. Few women are seen, perhaps because they do not often come to the attention of the referring agencies which are the source of many male clients. Few clients are middle or upper class professionals, probably because these make use of private treatment services. Most clients come on referrals, from their employers, the hospital, and the Solicitor General's office, which refers those convicted of impaired driving.

8.6.2 *Fort McKay - Health and Culture*

8.6.2.1 Fort McKay - Socio-Cultural Circumstances

Before construction of the Suncor plant, the people of Fort McKay were able to enjoy a "post-contact traditional" lifestyle, harvesting wild plant and animal resources, exchanging furs for trade goods, etc. With establishment of the Suncor, and thereafter the Syncrude operations in proximity to the community, Fort McKay residents reported growing scarcity of easily accessible animal and plant food resources. Employment at the oil sands plants during the early years was infrequent. More recently, however, many people from Fort McKay have obtained either direct or indirect employment from these companies.

These developments did not seriously challenge the more traditional cultural patterns of Fort McKay residents until the last 10 or 15 years, since many continued in traditional harvesting. The last ten years have seen many more people able to obtain oil sands-related employment, and inevitably there has been less pursuit of traditional resource harvesting. It should be noted, however, that as roads have become more numerous, and as more people have been able to purchase vehicles, their ease of access to distant hunting, trapping and fishing sites has improved significantly. Moreover, the Traditional Pursuits Survey conducted by OSLO (Concord Environmental Corporation and RMC Resource Management Consultants 1990) makes it clear that many people still spend much time hunting and trapping, still depend substantially on game food, and still expect that their children will continue to hunt and trap as well. Based on these data the Traditional Pursuits Survey report concludes, "These data give clear indications that:

- There is continuing strong interest among many Fort McKay people in trapping and hunting;
- The relevant interests and skills are being passed on to many in the younger generation;
- Trapping continues to be financially important;
- Hunting is important for people's diet;

- Many young people believe that it is possible to combine full-time oil sands employment with trapping" (Concord Environmental Corporation and RMC Resource Management Consultants 1990).

The continuing interest of community residents in both wage employment and traditional resource harvesting is further seen in responses of a wider cross section of residents to the Data Base Survey conducted by the Athabasca Native Development Corporation. These data also reflect "a strong interest among respondents in both maximizing retention of traditional pursuits and in having access to wage employment" (Concord Scientific and RMC Resource Management Consultants 1990). The OSLO SEIA sums up an extensive discussion: "In brief, Fort McKay appears to be making good progress in developing an adjustment to current conditions in the area which involves both the more traditional harvesting of renewable resources and taking advantage of the wage employment opportunities available" (Concord Environmental Corporation and RMC Resource Management Consultants 1990).

8.6.2.2 Fort McKay - Community and Family Health

While Van Dyke's study of Fort McKay (1978) described a community experiencing problems during a transition from semi-nomadic to community life, the last decade has witnessed major changes. It is now quite well equipped with infrastructure and facilities and has organized the Fort McKay Group of Companies to take advantage of the varied economic opportunities that its proximity to Syncrude offers. These developments have been both a consequence and a cause of increasing unity and confidence in the community. "Today the community of Fort McKay is proud of its progress, proud of its achievements, proud of the community, confident of its ability to deal with impending changes and eager to take on new opportunities and challenges" (Concord Environmental Corporation and RMC Resource Management Consultants 1990).

Among Aboriginal people the family has been the mainstay of community life. Contact with the modern/industrial socio-economy has undermined the Aboriginal family and kinship structures, greatly reducing their effectiveness at a time when culture conflict, disease and alcohol have ravaged many individuals. Nevertheless, though individual nuclear families might be damaged by these influences, the extended family, grandparents, uncles and aunts, have continued to provide backup support.

The available information suggests that Fort McKay residents have been through and survived the worst of these experiences. Recent demographic data suggest that there is "a good level of family stability in the community, and this impression is sustained by the observations of people who, over a period of years have seen the quality of life available to families in this community improve substantially." (Concord Environmental Corporation and RMC Resource Management Consultants 1990).

8.6.2.3 Fort McKay - Physical Health

As noted previously, Fort McKay is small, close to Fort McMurray, and depends upon the City's health facilities and services in most respects. It does, however, have a Health Clinic which is staffed by professionals from the District Health Unit, who are primarily concerned with public health and child care issues. There is also a Community Health Representative (CHR) who serves as liaison between hamlet residents and health service professionals in the City.

No statistical data are available which give indications of the health conditions of Fort McKay residents, but professionals with whom the matter has been discussed in the past indicate that these conditions are generally satisfactory. Infection levels tend to be low, in part as a result of the recently installed water and sewage systems and effective immunization efforts in the community.

"The elders in Fort McKay have expressed concern that environmental pollution in the area has caused a variety of ill-health conditions among community residents, but there are currently no hard data to bear this out" (Concord Scientific and RMC Resource Management Consultants 1990). The Fort McKay Position Paper on the environmental effects of the proposed OSLO Project (Fort McKay Environmental Services 1991) states: "The people of Fort McKay have experienced and documented short-term (health) reactions to the existing levels of pollutants. The long-term effects of low level exposure to many of the substances emitted by oil sands operations have not been fully determined".

At the present time, the main health concerns for this community relate to substance abuse, and the threats which may result either to the abuser him/herself from overdosing, or to his/her associates from associated violent behavior.

Fort McKay is dependent on mental health resources in Fort McMurray, having none of their own. Residents are handicapped by the distance they live from the city, but there are usually few difficulties in arranging access to city treatment facilities, when the need arises.

No statistical data are available relating to mental health conditions in Fort McKay. It seems likely that most residents of Fort McKay have now largely adjusted to the mental health threats that their proximity to the oil sands developments (city and plant) have caused them, though the process is no doubt continuing.

8.6.2.4 Fort McKay - Income Support

There are no social assistance workers in Fort McKay. Social assistance case workers visit the community one or more days a month from the Fort McMurray office to take assistance applications from new clients and to consult with old clients.

It is not possible to estimate the dependency rates per 1000 population for Fort McKay because of uncertainty in the numbers of people in these communities eligible for social assistance benefits. This results from the fact that while only non-Status Indians and non-Aboriginals are eligible, numbers of former Metis have gained Treaty status under the provisions of Bill C-31.

While this source of uncertainty can not be eliminated, it is probably only modestly significant. As in the case of Fort McMurray, employable cases comprise about one third of the total in Fort McKay.

8.6.2.5 Fort McKay - Substance Abuse

Fort McKay is at risk to influences tending to increase substance abuse because of their proximity to sources of supply in Fort McMurray. Substance abuse treatment programs are available to them only in Fort McMurray.

There are no data which give reliable indication of current or recent past levels of substance abuse in the community. "Soft" evidence from the reports of informed observers does indicate, however, that substance abuse is more of a chronic problem in predominantly Aboriginal communities than in Fort McMurray, and that such abuse does tend to increase in times of unusual prosperity. At the same time it seems clear that the incidence of such problems is tending to decline at a slow rate, with the passing years.

8.6.3 *Fort Chipewyan - Health and Socio-Cultural Circumstances*

Fort Chipewyan has a local health care facility, in the form of a Nursing Station.

There are no data providing significant information on physical health conditions in Fort Chipewyan. However, as in the case of Fort McKay, those familiar with these communities report that conditions are generally good. Again, the greatest threat to personal injury results from incidents of substance abuse.

Fort Chipewyan residents have a mental health resource in the local Nursing Station which is able to offer some very limited diagnostic and referral service.

Income dependency rates for Fort Chipewyan for 1990 are much higher than the rates in Fort McMurray or Fort McKay. Given the distance of Fort Chipewyan from major employment locations, it is not surprising that "employables" comprise about half of the case load in this community, as compared with one third in Fort McKay.

Fort Chipewyan has three facilities where liquor is served, one of which provides "off sales" as well. There are also three resources for dealing with substance abuse in this community, the Nursing Station, the Drop-In-Centre and the RCMP Detachment. The Nursing Station has facilities for treating drug-overdose patients, or for stabilizing their condition and evacuating them by air to hospital if this is necessary. They also make referrals to specialized treatment facilities in Fort McMurray or Edmonton.

The Fort Chipewyan Drop-In-Centre seeks to assist alcoholics through the work of the Director and two trained counselors. The Centre also provides facilities for meetings of Alcoholics Anonymous, Alanon and Alateen.

While the RCMP detachment has a primary responsibility for enforcing laws respecting substance abuse and injury to others, police patrols in winter also keep a lookout for substance abusers whose condition may put them at risk of freezing to death. Such persons may be taken home or placed in cells to "sober up" without being charged for an offence. (RCMP 1991).

8.7 Regional Law Enforcement

8.7.1 *Fort McMurray - Law Enforcement*

Police protection for the Fort McMurray District is provided by the Royal Canadian Mounted Police, with a detachment based in Fort McMurray, including officers based in Fort Chipewyan. The Fort McMurray contingent includes officers responding to city complaints, those assigned specifically to the rural detail, and some in the general investigation section, highway patrol, city traffic and crime prevention.

Historical data show Fort McMurray total crime rates are significantly higher than those for Alberta. Second, while the total crime rates declined from 1981 to 1985, to 160 per 1000 population, in 1988 the rate began to climb steadily, reaching 304 per 1000 in 1991. It is possible that this may have been influenced by increased effort on the part of the police, but the fact that there has been some increase in all categories except for sexual crimes, leads us to question this conclusion. The third, and perhaps most significant indication is the increase in assaults against persons, from 18 to 22 per 1,000 between 1990 and 1991. Again while this might be due to more effective police response, it does fit with reports cited in the family section that increased job insecurity and stress in the community may result in increased tendencies for physical confrontation.

Offences have decreased Province wide in the past 4 years. In the case of Fort McMurray the population has become more mature, less transient, and disposable incomes have become more stable. This has lead to a 5% decrease in annual reportable offices since 1992.

8.7.2 *Fort McKay - Law Enforcement*

Fort McKay does not have a local police detachment. Police protection is provided by the officers in the Fort McMurray detachment assigned to the rural detail. These officers patrol daily and have investigative responsibility for Fort McKay and several other communities in the Fort McMurray region.

The data show that the total offence rates were very high in 1981, more than four times those for Alberta. However, in 1986 and 1988 they declined to less than three times the provincial rate. Even acknowledging that the very high total Provincial Statutes offence rates were elevated largely because of driving offences of non-Aboriginal drivers, the remaining rates, like those for Fort McMurray city, were substantially higher than the provincial rates. It is the impression of the police that many offence rates in these communities are somewhat elevated, as a result of increased alcohol abuse associated with increased income. Recent discussions with RCMP staff indicate that break and enter, petty theft and spousal assaults have remained constant over the past 3 years (Inspector Colson, pers. comm.).

8.7.3 *Fort Chipewyan - Law Enforcement*

Fort Chipewyan has a local RCMP detachment. From the perspective of this SEIA the community is substantially buffered from the limited potential for Solv-Ex Project impacts by measure of their remoteness from Fort McMurray and from the plant site.

The community has had some experience with oil sands construction employment and experienced some adverse consequences resulting from offences associated with, or induced by, alcohol abuse. There are several Fort Chipewyan workers currently employed on a rotational basis by Syncrude.

Despite recent community growth, Fort Chipewyan RCMP also report a slight decrease in reportable offences over the past 3 years.

9.0 SOCIO-ECONOMIC IMPACT ASSESSMENT AND MITIGATION

9.1 Approach and Methods

The Socio-Economic Impact Assessment (SEIA) process for the proposed Solv-Ex Oil Sands Co-Production Experimental Project was designed to facilitate in the identification, evaluation, and resolution of impacts on, and benefits to, the human environment (social, cultural and economic). AGRA Earth & Environmental's (AEE's) team approach included the following objectives:

- identify the issues which are likely to be of significance so as to focus the efforts of both the study team and stakeholders and, therefore, maximize the use of available resources;
- identify the potential benefits and adverse impacts that may occur as a result of the project based on the specific issues previously identified;
- determine the significance of impacts that remain following these efforts; and
- recommend ways to monitor and report the benefits and adverse impacts.

Socio-economic impact assessment involves the potential interrelationship of an industrial or institutional project with almost every field of human endeavor and interest within a community. Therefore, it is subject to the dynamism inherent to those complex interactions.

Contacts with government officials were the first step in the community-based consultations leading to identification and assessment of potential project impacts. Completion of the SEIA required general and issue-specific information exchanges with government officials. At the local level, these included representatives of the Municipality of Wood Buffalo, the City of Fort McMurray, the Athabasca Chipewyan Band, Mikisew Cree First Nation and the Fort McKay Tribal Nation. At the provincial level, it included departments with potentially affected programs or responsibilities — both at the regional or local level and at headquarters. The Government of Canada was also included at the local level.

These discussions involved seeking input on recent changes to socio-economic circumstances and communicating the nature and extent of change in basic demand indicators which could be expected to result from the proposed project and assessing the implications for their area of responsibility. For a listing of the officials contacted, please refer to Section 10.2.

The general method used for this SEIA began with the gathering and analysis of baseline data. The objective was to endeavor to understand in quantitative terms, if possible, the pre-development situation on the issue in question, including the growth and/or change which could be expected in absence of a development initiative. With this as a context, the next step was to determine the key concerns which could occur in that sector of activity if the project were to go ahead.

These effects of the project, or impacts, were then related, where possible, to appropriate causal characteristics of the project plan. The most common example of the relationship is the link between project demands on the labour force, the population change which will result from that demand, and the effect or impact on provision of public and private services to service that population change. Often, however, the cause and effect link is not so obvious and the analysis component of the process becomes much more subjective, and therefore, more dependent on the judgment of the analyst in consultation with potentially affected stakeholders.

The underlying analytical framework for this SEIA was based primarily on empirical evidence of the effects of projects similar to the one proposed and relied heavily on the experience of the impact analysts. Therefore, it was often difficult to put a quantitative assessment value on impacts. A certain percentage increase or decrease in a variable may result in different degrees of concern in different communities, or in different times in the same community. Significance of impacts can generally be assessed by weighing potential duration, scope and magnitude.

For this SEIA, an issue-specific impact assessment was prepared and, where appropriate, mitigative measures were recommended to optimize the project's effects. The significance of projected impacts were evaluated and related as:

Neutral: those defined as falling within the normal range, therefore, they require no mitigation.

Low: those which are projected to only marginally exceed the normal range, causing no more than minor worsening of an existing condition and likely to occur for only a short time. These impacts require no consideration of mitigation.

Moderate: those which are definitely inconveniencing and may be costly in terms of time, money and/or human well-being, but do not pose a serious, long-term threat to the social or economic health of the community. A moderate impact usually represents an adverse consequence which should be countered using appropriate and timely mitigative measures, where possible.

High: those which are judged to be of a magnitude which would likely pose a serious threat to the social or economic health of the community. Mitigation must be attempted although there is no guarantee that it would be totally successful. At best, mitigation may reduce the severity of the impact to a more acceptable, but still noticeable, level.

The impact methodology is developed on three major assumptions:

- The construction workforce for the project will be housed in a permanent, on-site camp. The operational workforce will be accommodated in part in the on-site camp, and in part within the residential neighborhoods of Fort McMurray and other settlements in the region. Personnel will be transported to work on a daily basis by bus.

- The project will create significant opportunity for regional employment as well as enhanced business opportunities both regionally, provincially and nationally. Solv-Ex has placed, and continues to place, particular emphasis on local Aboriginal opportunities for employment and business.

- Data used in the issues analysis was obtained from published material. There is a wealth of information available from the past two decades of oil sands studies in the region. Solv-Ex believes the issues approach should address any outstanding or new concerns which have not been previously documented.

Although not always the case, the term "impact" as used in this SEIA is generally considered to be negative. The exception has to do with the positive economic effects of the various scenarios. Neutral and low impacts in relation to specific issues have not been discussed unless it is necessary to demonstrate that a key concern has, in fact, been addressed. The emphasis for both impacts and recommended mitigative measures has been placed in this SEIA on those issues which are judged as likely having a moderate to high negative potential.

Biophysical impacts of resource development are of increasing importance to people either directly (water quality, country food, public health, etc.), or indirectly (perceived quality of life, concern with nature, sustainable development, etc.). This high level of public concern makes the environment a socio-economic impact issue. Therefore, the SEIA team worked closely with the EIA consultant team (BOVAR-CONCORD Environmental) to ensure interdisciplinary cooperation.

9.2 Impacts on The Labour Force

The Solv-Ex approach to the processing of oil sands is to integrate the extraction of bitumen from the sands and the on-site upgrading of the bitumen, with a mineral extraction facility that will recover minerals from the fine clay fraction of the material rejected during bitumen extraction. This will require the construction and operation of several on-site buildings, processing equipment, storage tanks and structures. Pipelinable Crude Oil (PCO) and mineral products will be trucked to markets during the 7 year experimental period. Each of these activities will provide local and regional employment opportunities.

Solv-Ex is committed to encouraging Canadian and Albertan content in the supply of goods and services. To this point, preference has been already given to locally owned firms and organizations. This has been done within the framework of competitive fair market price, quality and delivery. Solv-Ex intends to interact with, among others, the local business organizations such as the Chamber of Commerce and the Northern Alberta Aboriginal Business Association in a very productive manner.

A local employment program will be developed which will result in a certain share of employment is made available to northern Aboriginal residents and organizations.

The construction phase of the project will result 500 person-years of direct employment in Alberta. Construction labour is anticipated to be 98+% Canadian with the majority of the labour sourced from the Fort McMurray region.

Direct and indirect manpower requirements, which include plant operating and hourly maintenance personnel, are estimated to be over 300 people by 1997. It is expected that most of the Solv-Ex operations labor force will be Canadian and from the regional and local area.

Solv-Ex will develop a training program based on project needs but no labour force short-falls can be identified at this stage. These projections are based on hiring in an under employed Canadian labour market. The Solv-Ex project will likely be too small to be able to support a project-specific On-Job-Training program; however, they are investigating options such as scholarships at Keyano College and the purchase of training spaces/positions at Syncrude and/or Suncor.

Industrial Benefits

Solv-Ex is committed to optimizing Canadian and Albertan content, subject to competitive quality and price, in manpower and services throughout the life of the project.

An expenditure estimate identifying each of the constituent elements of an oil sands project was developed. Costs associated with the provision of equipment, labor and bulk goods for each element where calculated. The preliminary analysis indicates that approximately $175 million in capital will be spent in developing the project. The estimate includes: Direct field costs (equipment, labor and bulks) and industrial costs (construction support, engineering/procurement, and pre-production). Overall, the industrial benefits associated with the construction of an oil sands plant are:

- The requirement for various engineering and support services;
- The requirement for labor in the project; and
- The requirement for bulk goods, equipment, materials and services to support the undertaking.

A significant proportion of the requirement for equipment will also be sourced in Canada and in Alberta.

9.2.1 *Construction Labour Force*

The Solv-Ex Project will be developed in two phases, with the following facilities:

Phase I: Mining, bitumen extraction and upgrading to produce PCO, including:

- Mine Development and Solids Handling
- Bitumen Extraction Plant
- Tailings Disposal
- Bitumen Upgrading
- Tankage
- Utilities
- Offsites and Infrastructure

Phase II: Extraction and separation of mineral values from clay fines in addition to the production of PCO, including:

- Mineral Extraction Plant
- Solid Products Handling
- Acid Plant
- Additional Power Generation Station

General information regarding the project's overall pre-construction and construction workforce requirement to mid-1997 is shown in Table 9.1. Based on the consultant's experience with other oil sands operations in the Fort McMurray area, it is assumed that 5% of the engineering/design complement required will be drawn from Fort McMurray. It is also assumed that 25% of the construction workforce required at the Bitumount site will be drawn from Fort McMurray.

No specific workforce breakdown by occupation or trade is available for the construction activities. It is anticipated that the construction demands of this project will not have any effect on the availability of construction workforce supply in the province of Alberta, that is, it is unlikely that the demands of the construction activity will cause or exacerbate any specific trade shortages (R. Nichol, pers comm). Given the current and projected level of activity of the construction industry in the province, it is likely that the construction case would provide significant economic benefit by utilizing projected excess capacity.

9.2.2 *Operations Labour Force*

Table 9.2 shows the estimated operations and maintenance staff ramp-up for the Solv-Ex Oil Sands facilities through to mid-1997.

Table 9.1 Solv-Ex Oil Sands Project construction staffing.

	3/95	6/95	9/95	1/96	6/96	1/97	6/97	9/97
Pre-Construction (Eng. Design and Support)	40	80	100	100	75	75	75	30
Construction	0	50	250	350	300	250	250	50
Total	40	130	350	450	375	325	325	80

Source: Solv-Ex Corporation (1995)

Table 9.2 Solv-Ex Oil Sands Project operations/maintenance staffing.

	9/95	1/96	6/96	1/97	6/97	9/97
Mine	10	15	75	150	170	170
Operations	0	0	50	94	115	115
Maintenance	0	0	20	52	52	66
Total	10	15	145	296	337	351

Source: Solv-Ex Corporation (1995)

Operations staffing estimates were developed on the basis of the following criteria and guidelines:

- Past and present experience of Suncor and Syncrude in the area;

- The co-production plant will be located in an isolated area 85 km north of Fort McMurray;

- The plant will employ non-union personnel and contractors;

- Maximum use of existing infrastructure and services in Fort McMurray; and

- Salary levels will be similar to present demand/supply market average wages in Fort McMurray.

It should be noted that while the contractor workforce makes up a significant portion of the total operations workforce, no estimates of its occupational profile are available. Some of the tasks that are proposed to be contracted to external contractors include:

- mining operation (10 000 BPCD);
- security system (two security guards per shift);
- transportation (personnel and material);
- camp operation (125 person camp on-site).

Phase I and Phase II operations and maintenance manpower requirements, by skills area, are shown in Table 9.3.

Solv-Ex estimates annual manpower costs (salaries and benefits) for Phase I to be $6.08 million and $7.46 million for Phase II. Total annual costs for external contractors, including manpower costs, are estimated at $15.08 million during both Phase I and II. As operations at Suncor and Syncrude show that the total maintenance costs are split approximately 33% and 67% between manpower and materials, respectively, we might estimate that external contractor manpower costs are about $5 million per year.

Solv-Ex has identified that the staffing positions shown in Table 9.3 have been subdivided into several administrative/departmental units as follows:

- Management/Administration
- Laboratory
- Engineering
- Mining, Extraction and Mineral Processing and Alumina Production
- Upgrading
- Utilities and Offsites
- Maintenance

Table 9.3 Solv-Ex Oil Sands Project Phase I and II operations/maintenance staffing.

	Phase I	**Phase II**
Management	8	8
Professional/Supervisory	5	8
Technical	13	18
Clerical	13	16
Operators	43	47
Trades	29	37
Labourers	35	45
Total	146	179

Source: Solv-Ex Corporation (1995)

Given recent uncertainty about the long term level of employment at the two existing commercial oil sands mining and bitumen extraction facilities, the advent of these operational positions must be seen as having a significant beneficial effect on the Fort McMurray and Fort McKay labour market.

9.3 Impacts on the Regional Population

This Section of the SEIA attempts to predict population effects caused by the Solv-Ex development, primarily on the City of Fort McMurray. A computer model, based on a more complex computer model named I.M.P.A.C.T. developed by Alberta Municipal Affairs, is used. The Demographic Module of the I.M.P.A.C.T. Model has been modified by the consultant for the purpose of this SEIA. An expanded description of the Demographic Module of the I.M.P.A.C.T. Model and its modifications is found in Section 9.3.2.1. The reader will note that all population projections presented here will be placed in the context of an assessment timeframe ending in the year 2006. This is to correspond to the nearest census year following the project activity period which will provide for ease of future monitoring and analysis and broad comparability with any other demographic projection studies/publications.

9.3.1 *Population Forecasts for Communities in Census Division 16*

The Solv-Ex application is not anticipated to have any effect which will cause a significant population increase or decrease in any of the smaller Aboriginal communities of the region–Fort McKay, Fort Chipewyan, Janvier, Conklin and Anzac (including the Gregoire Lake Reserves). Even though there may be an increase in long-term regional employment opportunities, there will not be the likelihood that there will be any in-migration to these communities due to the large under-employed labour force. It is likewise assumed there will be no inter-community migration (for example, from Fort Chipewyan to Fort McKay).

Regardless, there will likely be growth in all of the regional communities due to net natural increase. The Alberta Bureau of Statistics published "Population Projections, Alberta Census Divisions, 1987-2001", in October 1988. These projections are based on 1986 Census of Canada data. This report suggests growth rates in the northern parts of the province will outstrip those of the south, due primarily to the generally higher fertility rates and overall younger population in the northern aboriginal communities combined with an almost insignificant out-migration level. In fact, the Alberta Bureau of Statistics contends that C. D. 16 (Fort McMurray) will likely show the highest rate of *natural growth* in the province. "These census divisions are expected to grow in the range of 1.6-2.0% per annum during the next fifteen years. Division 16 (Fort McMurray) shows an annual growth rate of 2.0%, highest in the province."

These projections are very likely to be optimistic given the reality of the first few years of actual growth as compared to the projections. What is of note is the fact that the Fort McMurray C. D. 16 did grow at a rate of about 1% over the period 1986 to 1991 after an initial decline in 1987 and 1988. It is likely that the growth in the C. D. over this time was mostly made up in the rural communities and not in the City of Fort McMurray as the city's population has declined slightly (0.7%) from 34,949 to 34,706 over the intercensal period.

9.3.1.1 Fort McKay - Population Impacts

To determine the 2006 population of Fort McKay, a growth rate of 2.0% per annum has been used, as recommended by the Alberta Bureau of Statistics.

Using the 1995 Fort McKay municipal census estimate of 332 people and a growth rate of 2.0% per year, it has been estimated that the population of Fort McKay in 2006 will be about 413 persons.

Geographically, Fort McKay is in a favoured economic position with regard to the project as it is the community most proximate to the proposed Solv-Ex Oil Sands Plant. This ensures that, if there is a demonstrated capability to participate in the project, Fort McKay residents may have the greatest *per capita* opportunities for employment and business development during both construction and operations phases of the project.

One item to consider is whether former Fort McKay residents which are currently employed by either Suncor or Syncrude or other Fort McMurray contractors decide to relocate back to Fort McKay to work at the Solv-Ex Plant. If this scenario were to develop, a small population increase due to net in-migration might occur in Fort McKay during the construction phase and/or the operations phase.

9.3.1.2 Fort Chipewyan - Population Impacts

To determine the 2006 population of Fort Chipewyan, a growth rate of 2.0% per annum has been used, as recommended by the Alberta Bureau of Statistics.

Using the 1995 Fort Chipewyan municipal estimate of about 1,200 people and a growth rate of 2.0% per year, the estimated population of Fort Chipewyan in 2006 will be about 1492 persons.

Fort Chipewyan is not in a favoured economic position with regard to the project as access to the plant site is either poor (no road) or very expensive (fly/drive). It the study area community least proximate to the proposed Solv-Ex Oil Sands Plant. Fort Chipewyan's isolation from the rest of the study area probably ensures that it will be only marginally impacted by the project.

Fort Chipewyan's isolation will ensure that the operations phase has marginal impact. In fact, the community may experience some outward migration to Fort McMurray because of the increased experience with wage employment (Syncrude fly-in, fly-out crew rotation) and a more general movement towards preference for an urban lifestyle.

9.3.2 *Population Projections - City of Fort McMurray*

9.3.2.1 I.M.P.A.C.T. Model

The estimates of population effect in this Section are made with the aid of the Demographic Module from the I.M.P.A.C.T. Model (Impact Model for Planning Alberta Communities over Time), developed by the Alberta Department of Municipal Affairs, Planning Services Division, Research and Development Branch. This forecasting/planning tool basically consists of a series of statistical summary modules which are linked to and driven by demographic changes. It is important to note that the I.M.P.A.C.T. model was designed as a growth scenario comparative analysis tool and functions better in this role than as a predictive tool for any single development. The Model was used extensively for the City of Fort McMurray in the OSLO SEIA and is described fully in that document. However, a brief description of the Demographic Module is warranted here.

The Demographic Module starts with the existing population expressed in age group characteristics and adds (or subtracts) incremental new growth (from the basic direct resident operating workforce of Solv-Ex, the indirect workforce induced by economic activity and the assumed dependents of the aforementioned) with their own unique age group characteristics. The product is aged annually and fertility-mortality rates are included. The net result is annual incremental (or decremental) growth that can be used to generate estimates of what infrastructure will be required to support it.

A shortcoming of this Module as it was designed is its inability to account for net migration. The Demographic Module, in essence, assumes that net migration is zero; that is, equal numbers of people move in and out each year (or none move in or out) – contrary to the reality of the recent historical past which shows a net population loss from the City. Therefore, this Module has been modified. Given recent historical trends that show that a generally flat-line population maintenance trend would be a conservative up-side estimate, it was determined that a reasonable, estimated net annual growth factor for planning purposes of 0.00% per annum should be assumed. Given a net natural increase (births minus deaths) in the order of 20.00 per 1000 (2.00% per annum - based on 1990 historical figures) used in the Module, it was apparent that a factor was needed to reduce the net annual growth rate to 0.00%. This factor was calculated to be approximately -2.00% per annum. This assumed out-migration factor sub-module was then appended to the Demographic Module.

It is the longer term sustainable demographic effects which will be the most important determinants of impact. The following population impact estimates, it should be noted, are order-of-magnitude approximations related to Solv-Ex's annual total resident workforce complement through the year 2006. It is also important to note that the Module assumes that all workforce positions are resident in Fort McMurray. This is obviously not the case as some positions will reside in other regional communities. However, by making this assumption, the likelihood of under-estimating the potential population impact on the city is significantly reduced. Therefore, this method can be considered a conservative estimate.

The resident workforce does not include any persons who at any given time may reside temporarily in Solv-Ex's camp facilities on site, especially during construction. These persons, however, do contribute to the indirect population effects. For the purposes of the Demographic Module, then, a conversion factor was applied which would allow the model to "see" non-resident effects as resident effects. Therefore, for input to the I.M.P.A.C.T. Model, the incremental/decremental, combined resident/non-resident, direct workforce required per year was calculated.

Using a basic to non-basic employment ratio for these persons of 5:1, a direct resident equivalent workforce factor was incorporated to the ongoing Solv-Ex operations complement. It is assumed that if 1 direct, resident workforce position would generate 1 indirect, resident employment opportunity, and that 5 direct, non-resident workforce positions would generate 1 indirect, employment opportunity, then 5 direct, non-resident workforce positions could be equated to 1 direct, resident workforce position, thereby allowing the entering of one Basic (direct) Workforce incremental/decremental value per year to the Demographic Module. (The 5:1 ratio reflects the fact that this direct, non-resident workforce will be housed in an on-site camp remote from Fort McMurray and is based on previous experience.)

This equivalency factoring was done primarily to accommodate the Basic Workforce information entry to the I.M.P.A.C.T. Model, which in its present form can only be programmed to account for the application of a single "Basic to Non-Basic" employment ratio. This factor is the number of non-basic, indirect, resident employment opportunities generated by increments/decrements of basic, direct, resident (and resident-equivalent) workforce positions. The ratio used in the Model for the base case and production increase scenarios is 1:1 and was developed in consultation with Alberta Municipal Affairs and the City of Fort McMurray.

Table 9.4 shows the combined, annual direct, resident and resident-equivalent workforce through the year 2006 for Solv-Ex's production scenario. The differential between any given year and the preceding year is entered in the incremental (in this case, decremental) Basic Workforce line of the Demographic Module.

9.3.2.2 Population Effect - Fort McMurray

The I.M.P.A.C.T. Model is most effective when used as a "comparative" tool as opposed to a "predictive" tool. This means that variables in input data can be compared in any number of "scenario runs" to see the differences between the estimated results. The resultant output, then, was generated at the end of a series of many scenario runs and is the one which represents the "most likely" up-side case for the Solv-Ex production scenario.

The model is initialized from 1991 Census data, so the scenario begins there. However, Solv-Ex effects are not in evidence until 1995 so the population changes shown by the model from 1991 to 1995 are not relevant to the case. In fact, the only thing of significance is the population effect that is the differential between what the model would predict given no Solv-Ex project and that which it would predict using the workforce numbers shown in Table 9.4.

As can be seen in Table 9.4, Solv-Ex's resident equivalent workforce is projected to start at 115 in 1995, increase to a peak of 453 in 1997 during plant construction and then decline to 349 in 1998. It should be noted that after the year 1998, the resident equivalent workforce is assumed to be constant at that year's value.

Because there are already so many population-effect-related activities ongoing and forecast in Fort McMurray due to the changes at both Suncor and Syncrude operations, the effects on the population due to Solv-Ex activities will likely be minor and short-term in comparison. In an effort to show the potential population effects of the Solv-Ex project in isolation from these other activities, the Demographic Module was run as a base case with no Solv-Ex (or Suncor or Syncrude) activity shown.

Table 9.4 Combined Solv-Ex resident/resident-equivalent workforce 1995 - 2006.

Year	Workforce
1995	115
1996	290
1997	453
1998	349
1999	349
2000	349
2001	349
2002	349
2003	349
2004	349
2005	349
2006	349

Source: Solv-Ex, 1995, resident-equivalent values calculated by AEE

This is summarized in Table 9.5 and shown graphically in Figure 9.1. The Demographic Module was run using the Solv-Ex workforce information in Table 9.4. The resultant population effects of the Solv-Ex production scenario, as generated by the Demographic Module, are summarized in Table 9.6 and are shown graphically in Figure 9.2. Figure 9.3 shows the difference between the two scenarios which gives a net population effect that might reasonably be attributed to the Solv-Ex project.

There is enough commercial and private housing and land available at Fort McMurray to accommodate the project's operation workforce and any spin-off population increase which would result from the project. There is sufficient surplus capacity within the physical and social infrastructure of the City of Fort McMurray to accommodate the permanent workforce as currently projected.

Housing construction activity in Fort McMurray has fluctuated widely over the years in response to local economic conditions as it has, in fact, for Alberta as a whole which demonstrates the ability of the Alberta housing construction industry, generally, and that of Fort McMurray, specifically, to respond to large and rapid changes in demand.

With this as background, the impact of the housing sector can be addressed. Housing development is an impact which is expressed in direct proportion to population growth and the population effects related directly to the Solv-Ex Project.

Population growth stimulated directly by the Solv-Ex Project is not expected to reach the threshold levels needed to trigger additional demands for major capital investments in infrastructure, the impact is judged to be neutral. The same conclusion should pertain to impact on both commercial and industrial real estate.

Accordingly, no mitigative measures are considered necessary for community development impacts of the Solv-Ex Project.

9.4 Solv-Ex Project Economic Assessment

9.4.1 *Objective and Scope*

The economic assessment includes a financial description of the Project, an Alberta and Canada benefit-cost analyses, and an Alberta economic impact analysis. The scope of the economic analysis reflects the Board's application guidelines for a commercial crude bitumen recovery and upgrading project, and discussions with Board staff.[1]

An application is being made to the AEUB for an operating permit term of approximately seven years, from Quarter 4, 1996 to July 1, 2002. The economic analysis relates to the "experimental phase" only, for which application is being made. If the experimental facility is successful, and

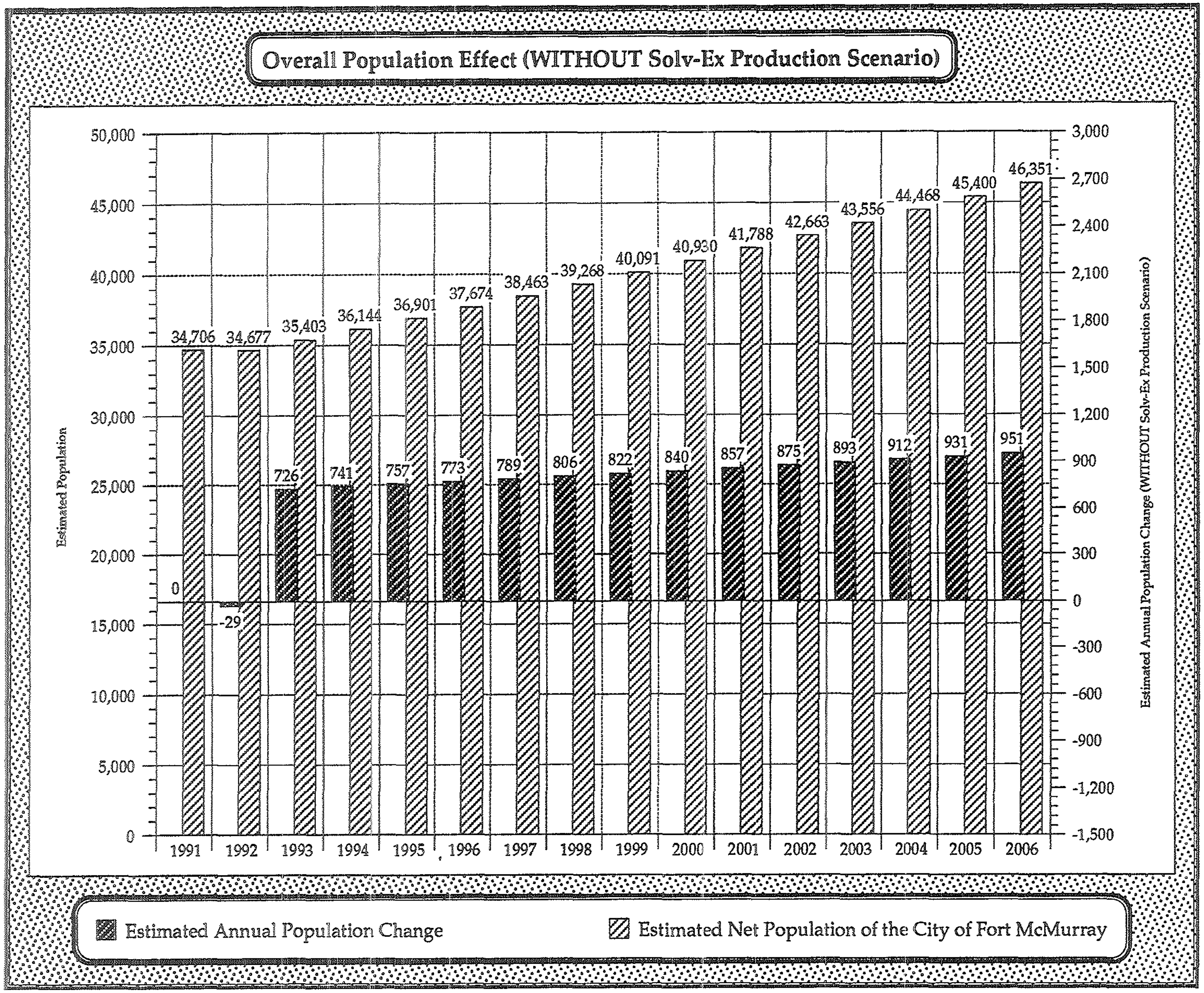
[1] *Guidelines Respecting an Application for a Commercial Crude Bitumen Recovery and Upgrading Project*, ERCB Guide G-23, Alberta Environment and Energy Resources Conservation Board, September 1991, Section 3.

Table 9.5 Demographic module - without Solv-Ex.

WITHOUT SOLVEX SCENARIO			1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. BASIC WORKFORCE (annual increment)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11. BASIC:NONBASIC EMPLOYMENT RATIO			0.00															
2. NONBASIC WORKFORCE (ann. increment)				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. TOTAL WORKFORCE REQ'D (ann. incr.)				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. UNEMPLOYMENT RATE = 9.6% (1995 Estimate)			0.096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. TOTAL WORKFORCE (Annual Increment)				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. TOT. ACCUMUL. COMMUNITY WKFCE			18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051	18,051
7. TOTAL LABOUR FORCE																		
71.Head of Household Ratio (33%) (1991 Census)			0.33															
72.Number of New Households				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73.New Growth Household Size (1991 Census)			3.07															
8. TOT. ANNUAL INDUCED POP'N GROWTH				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9. EST. GROWTH RATE-21.40 BIRTHS / 1000 (1990)				728	742	758	773	790	806	823	840	858	876	894	913	932	952	972
10. EXISTING POPULATION (1991)			34,706															
	INITIAL %	NEW%																
0 TO 4	10.0	10.0	3,471	3,504	3,546	3,594	3,649	3,709	3,773	3,842	3,914	3,989	4,067	4,148	4,231	4,317	4,405	4,496
5 TO 9	10.3	10.3	3,575	3,554	3,544	3,544	3,554	3,573	3,600	3,635	3,676	3,724	3,777	3,835	3,897	3,964	4,035	4,109
10 TO 14	9.7	9.7	3,366	3,408	3,437	3,459	3,476	3,491	3,508	3,526	3,548	3,574	3,604	3,638	3,678	3,722	3,770	3,823
15 TO 19	8.5	8.5	2,950	3,033	3,108	3,174	3,231	3,280	3,322	3,359	3,393	3,424	3,454	3,484	3,515	3,547	3,582	3,620
20 TO 24	8.3	8.3	2,881	2,894	2,922	2,959	3,002	3,048	3,094	3,140	3,184	3,226	3,265	3,303	3,339	3,374	3,409	3,443
25 TO 29	11.0	11.0	3,818	3,630	3,483	3,371	3,289	3,231	3,195	3,175	3,168	3,171	3,182	3,199	3,219	3,243	3,270	3,297
30 TO 34	12.5	12.5	4,338	4,234	4,113	3,987	3,864	3,749	3,645	3,555	3,479	3,417	3,368	3,331	3,304	3,287	3,278	3,277
35 TO 39	10.5	10.5	3,644	3,783	3,873	3,921	3,934	3,920	3,886	3,838	3,781	3,721	3,660	3,602	3,547	3,499	3,456	3,421
40 TO 44	8.2	8.2	2,846	3,006	3,161	3,303	3,427	3,528	3,607	3,663	3,698	3,714	3,716	3,705	3,684	3,657	3,625	3,591
45 TO 49	4.9	4.9	1,701	1,930	2,145	2,348	2,539	2,717	2,879	3,025	3,152	3,261	3,352	3,425	3,481	3,521	3,548	3,564
50 TO 54	3.1	3.1	1,076	1,201	1,347	1,506	1,675	1,848	2,021	2,193	2,359	2,518	2,667	2,804	2,928	3,038	3,135	3,218
55 TO 59	1.4	1.4	486	604	723	848	980	1,119	1,264	1,416	1,571	1,729	1,887	2,043	2,195	2,341	2,481	2,612
60 TO 64	0.8	0.8	278	319	376	446	526	617	717	827	944	1,070	1,202	1,339	1,479	1,622	1,766	1,909
65 TO 69	0.3	0.3	104	139	175	215	261	314	375	443	520	605	698	799	907	1,021	1,141	1,266
70+	0.5	0.5	174	194	222	257	300	352	415	490	579	683	804	943	1,103	1,284	1,489	1,717
11. NATURAL DEATH RATE - 1.40 DEATHS/1000				**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**59**	**60**	**61**	**62**	**64**	**65**	**66**
12. TOTAL POP'N (before out-migration factor)			34,706	35,384	36,125	36,882	37,654	38,443	39,248	40,070	40,909	41,766	42,640	43,533	44,445	45,376	46,326	47,296
13. ASSUMED OUT-MIGRAT. FACTOR/YEAR (%) =			(2.0%)	(708)	(723)	(738)	(753)	(769)	(785)	(801)	(818)	(835)	(853)	(871)	(889)	(908)	(927)	(946)
14. TOTAL POP'N (after out-migration factor)				**34,677**	**35,403**	**36,144**	**36,901**	**37,674**	**38,463**	**39,268**	**40,091**	**40,930**	**41,788**	**42,663**	**43,556**	**44,468**	**45,400**	**46,351**
15. ANNUAL GROWTH				**(29)**	**726**	**741**	**757**	**773**	**789**	**806**	**822**	**840**	**857**	**875**	**893**	**912**	**931**	**951**
16. PERCENTAGE GROWTH PER ANNUM				(0.08)	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09

with modifications developed by AGRA Earth & Environmental Limited
16-May-95

Figure 9.1 Overall population effect - without Solv-Ex.



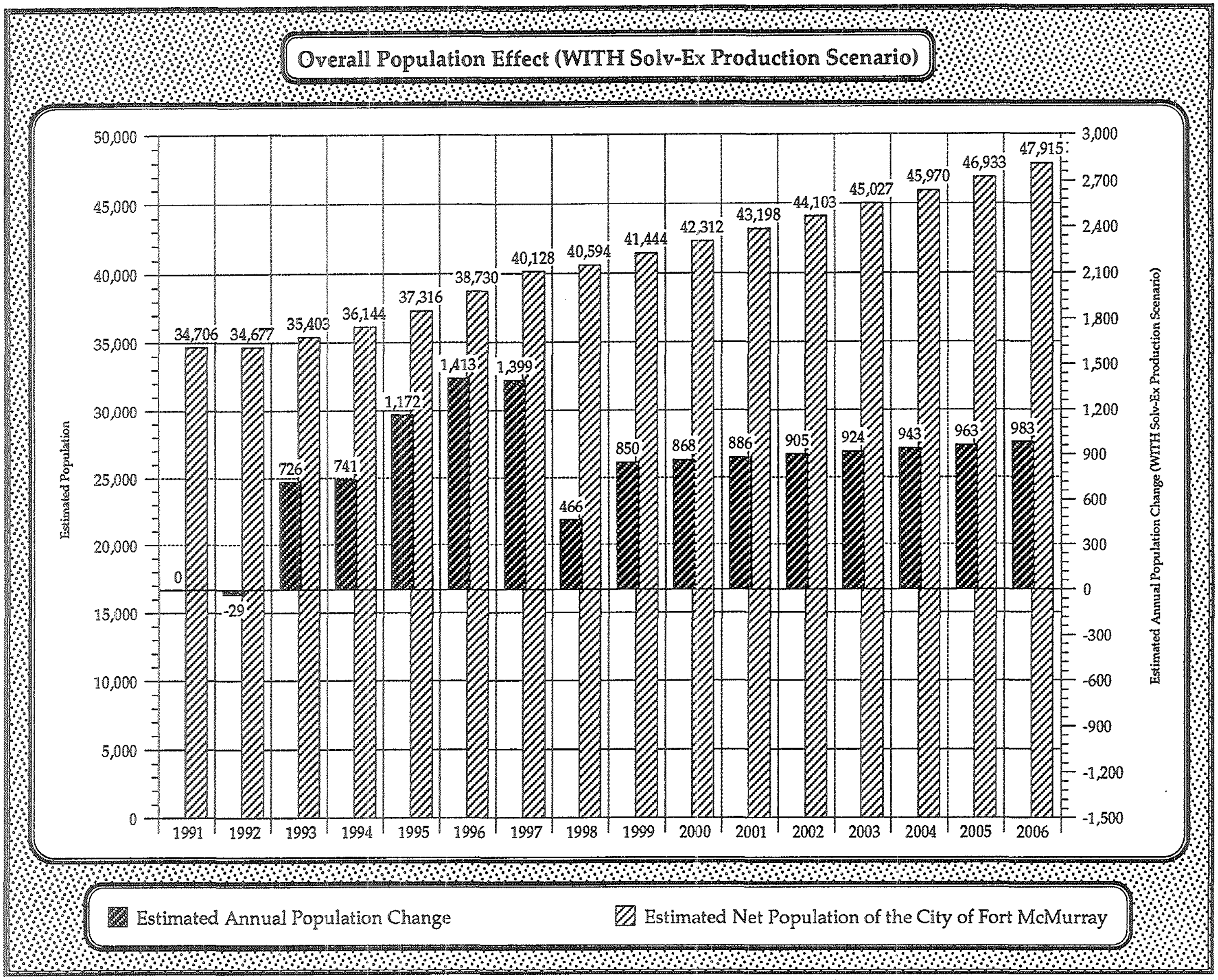
with modifications developed by AGRA Earth & Environmental Limited
16-May-95

Table 9.6 Demographic module - with Solv-Ex.

SOLV-EX PRODUCTION SCENARIO	INITIAL %	NEW%	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1. BASIC WORKFORCE (annual increment)			**0**	**0**	**0**	**0**	**115**	**175**	**163**	**(104)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
11. BASIC:NONBASIC EMPLOYMENT RATIO			**1.00**															
2. NONBASIC WORKFORCE (ann. increment)				**0**	**0**	**0**	**115**	**175**	**163**	**(104)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
3. TOTAL WORKFORCE REQ'D (ann. incr.)				**0**	**0**	**0**	**230**	**350**	**326**	**(208)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
4. UNEMPLOYMENT RATE = 9.6% (1995 Estimate)			0.096	0	0	0	22	34	31	(20)	0	0	0	0	0	0	0	0
5. TOTAL WORKFORCE (Annual Increment)				**0**	**0**	**0**	**252**	**384**	**357**	**(227)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
6. TOT. ACCUMUL. COMMUNITY WKFCE			**18,051**	**18,051**	**18,051**	**18,051**	**18,303**	**18,687**	**19,043**	**18,816**	**18,816**	**18,816**	**18,816**	**18,816**	**18,816**	**18,816**	**18,816**	**18,816**
7. TOTAL LABOUR FORCE																		
71.Head of Household Ratio (33%) (1991 Census)			0.33															
72.Number of New Households				**0**	**0**	**0**	**83**	**127**	**118**	**(75)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
73.New Growth Household Size (1991 Census)			3.07															
8. TOT. ANNUAL INDUCED POP'N GROWTH				**0**	**0**	**0**	**424**	**646**	**600**	**(383)**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
9. EST. GROWTH RATE-21.40 BIRTHS / 1000 (1990)				728	742	758	773	799	829	859	869	887	905	924	944	964	984	1,004
10. EXISTING POPULATION (1991)			34,706															
0 TO 4	10.0	10.0	3,471	3,504	3,546	3,594	3,691	3,816	3,942	3,974	4,048	4,125	4,206	4,289	4,375	4,464	4,555	4,648
5 TO 9	10.3	10.3	3,575	3,554	3,544	3,544	3,598	3,683	3,772	3,766	3,808	3,856	3,910	3,969	4,033	4,101	4,174	4,250
10 TO 14	9.7	9.7	3,366	3,408	3,437	3,459	3,517	3,596	3,671	3,654	3,677	3,703	3,733	3,769	3,809	3,854	3,903	3,957
15 TO 19	8.5	8.5	2,950	3,033	3,108	3,174	3,267	3,372	3,468	3,476	3,512	3,545	3,576	3,608	3,640	3,674	3,710	3,748
20 TO 24	8.3	8.3	2,881	2,894	2,922	2,959	3,038	3,137	3,234	3,249	3,294	3,338	3,379	3,419	3,456	3,493	3,529	3,565
25 TO 29	11.0	11.0	3,818	3,630	3,483	3,371	3,335	3,347	3,371	3,301	3,291	3,292	3,301	3,316	3,337	3,361	3,387	3,416
30 TO 34	12.5	12.5	4,338	4,234	4,113	3,987	3,917	3,881	3,850	3,706	3,625	3,558	3,505	3,464	3,435	3,415	3,404	3,401
35 TO 39	10.5	10.5	3,644	3,783	3,873	3,921	3,979	4,034	4,067	3,983	3,928	3,867	3,805	3,745	3,689	3,638	3,594	3,556
40 TO 44	8.2	8.2	2,846	3,006	3,161	3,303	3,462	3,618	3,751	3,783	3,823	3,844	3,848	3,840	3,821	3,795	3,763	3,729
45 TO 49	4.9	4.9	1,701	1,930	2,145	2,348	2,560	2,772	2,971	3,108	3,243	3,359	3,456	3,534	3,595	3,640	3,671	3,690
50 TO 54	3.1	3.1	1,076	1,201	1,347	1,506	1,688	1,882	2,079	2,245	2,418	2,583	2,738	2,882	3,012	3,129	3,231	3,319
55 TO 59	1.4	1.4	486	604	723	848	986	1,135	1,293	1,445	1,605	1,767	1,930	2,092	2,250	2,402	2,548	2,684
60 TO 64	0.8	0.8	278	319	376	446	529	626	732	842	962	1,091	1,226	1,367	1,512	1,660	1,808	1,956
65 TO 69	0.3	0.3	104	139	175	215	263	318	381	450	529	615	710	814	924	1,042	1,165	1,294
70+	0.5	0.5	174	194	222	257	302	358	425	499	589	695	818	960	1,123	1,307	1,516	1,749
11. NATURAL DEATH RATE - 1.40 DEATHS/1000			,	**50**	**51**	**52**	**53**	**55**	**57**	**58**	**59**	**61**	**62**	**63**	**64**	**66**	**67**	**69**
12. TOTAL POP'N (before out-migration factor)			34,706	35,384	36,125	36,882	38,078	39,520	40,947	41,423	42,290	43,176	44,080	45,003	45,946	46,908	47,890	48,893
13. ASSUMED OUT-MIGRAT. FACTOR/YEAR (%) =			(2.0%)	(708)	(723)	(738)	(762)	(790)	(819)	(828)	(846)	(864)	(882)	(900)	(919)	(938)	(958)	(978)
14. TOTAL POP'N (after out-migration factor)				**34,677**	**35,403**	**36,144**	**37,316**	**38,730**	**40,128**	**40,594**	**41,444**	**42,312**	**43,198**	**44,103**	**45,027**	**45,970**	**46,933**	**47,915**
15. ANNUAL GROWTH				**(29)**	**726**	**741**	**1,172**	**1,413**	**1,399**	**466**	**850**	**868**	**886**	**905**	**924**	**943**	**963**	**983**
16. PERCENTAGE GROWTH PER ANNUM				(0.08)	2.09	2.09	3.24	3.79	3.61	1.16	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09

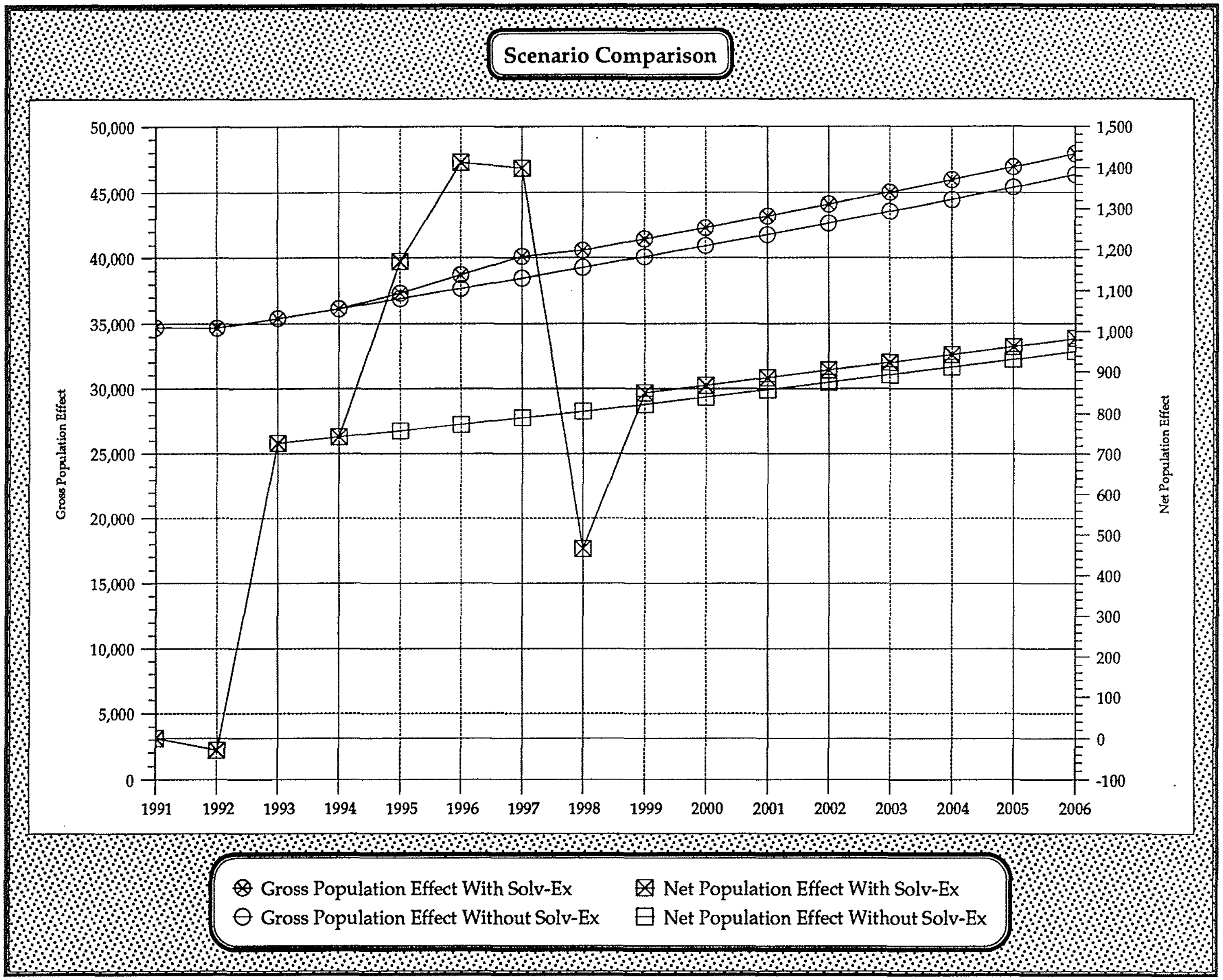
with modifications developed by AGRA Earth & Environmental Limited
16-May-95

Figure 9.2 Overall population effect - with Solv-Ex.



with modifications developed by AGRA Earth & Environmental Limited
16-May-95

Figure 9.3 Scenario comparison - population effect.



with modifications developed by AGRA Earth & Environmental Limited
16-May-95

future business conditions and fiscal terms are favourable, subsequent applications may be made for a commercial project.

9.4.2 *Project Definition*

Solv-Ex proposes to extract 14 kbpd of bitumen from oil sands mined on Lease 5 (the former Bitumount Lease) located 85 km north of Fort McMurray on the east side of the Athabasca River. The Company proposes to demonstrate the technical and economic viability of co-producing crude oil and minerals using technology it has developed. The Project involves site development, mining oil sands (truck, shovel and trailing dragline), and constructing bitumen extraction and upgrading facilities and a minerals extraction plant (and related ancillary and utility facilities). The features of the proposed co-production technology include: joint recovery of oil and minerals from oil sands in an integrated facility; low SO_2 emissions; dry tailings disposal suitable for reclamation; no caustic or solvent addition for bitumen extraction; and internal hot water treatment and recycle.

During the experimental phase, the crude oil output will be transported by truck to terminals (e.g., Cold Lake) for use as a diluent for heavy crude oil and subsequent sale to North American refiners. The mineral co-products will be trucked to a rail terminal south of Ft. McMurray or trucked directly to markets in North America. Alumina is used in the production of aluminum, and potassium sulphate and ferrous sulphate are industrial and agricultural minerals with a wide range of uses including chemical fertilizers.

The Solv-Ex Project is assessed f.o.b. the plant gate, with input costs including transportation charges to the plant site and the marketable outputs valued at the plant gate. However, for the benefit-cost analysis, other effects such as transportation of products to market and off-site public infrastructure requirements are considered. All monetary values are expressed in constant 1995 dollars.

9.4.3 *Information Sources*

Solv-Ex provided the basic data relating to the proposed Project (production, value of output, costs, and employment). The provincial economic impact assessment uses input-output multipliers from Alberta Treasury Bureau of Statistics.

9.4.4 *Financial Flows And Employment*

Table 9.7 summarizes the cumulative financial and employment data for the Project. It provides a description of the Project and much of the input data for the benefit-cost and economic impact analyses. Royalties and taxes are yet to be determined.

9.4.4.1 Financial Summary

Revenues are based on a \$16.77/bbl (1995\$) constant plant gate oil price (for 22.9° API specific gravity, 3.5% sulphur quality) during the experimental phase. An alumina plant gate price of \$300/tonne is assumed, and the weighted average plant gate sulphates price is \$212/tonne (\$1995). Solid sulphur by-product production will be used in the minerals extraction process. The crude oil

Table 9.7 Solv-Ex Experimental Project cumulative incremental financial flows and employment, 1995 to mid-2002.

	Millions 1995$
Sales Revenue (crude oil and minerals)	452.6
Operating Costs:	
Utilities (natural gas & electricity)	72.4
Labour	61.0
Property Taxes	0.0
Supplies & Chemicals	7.9
Maintenance Materials	10.5
External Contractors	123.4
Total	275.1
Capital Expenditures	168.8
Net Cash Flow (Before Taxes and Royalties)	8.7
	Person-Years[a]
Engineering & Design/Construction Workforce	500
Operations Workforce	2011

[a] Person-year equals 1,800 hours.

Source: Solv-Ex Corporation (1995)

sales are 200 k bbls in 1996 rising to 3600 k bbls by 1998, and remaining at that amount. Annual minerals production equals 15 k tonnes of alumina in 1997 rising to 64 k tonnes in 1998 and beyond, and 10 k tonnes of sulphates in 1997 rising to 25 k tonnes in 1998 and beyond. Cumulative oil production over the applied-for permit term equals about 20 million barrels and minerals production equals 425 k tonnes.

Operating costs by component are also shown in Table 9.7. They include maintenance capital to sustain the facilities as-built. The weighted average regional allocation of the total operating costs is about 30% Fort McMurray region, 55% other Alberta, 10% other Canada, and 5% foreign.

The capital expenditures include pre-construction[1] and initial construction expenditures[2] for phased installation of the bitumen and minerals components. The estimated regional distribution of the overall construction expenditures is 20% Fort McMurray region, 40% other Alberta, 25% other Canada, and 15% foreign. About 30% of the cumulative capital expenditures relate to labour costs (wages, salaries, and benefits).

The calculations assume 100% equity financing. The fiscal terms respecting royalties and income taxes are yet to be determined. Investment tax credits and accelerated capital cost allowance for scientific research and experimental development are available with respect to qualifying capital and operating costs prior to the Project attaining commercial status.

Net cash flow equals sales revenue less operating costs less capital expenditures. The net cash flow is before royalties and income taxes.

Solv-Ex is a United States based company with offices in Canada. United Tri-Star Resources Ltd. is the Canadian joint venture partner in the Project. The ownership of the Applicants is currently 10% Canadian and 90% foreign. The ownership share of Alberta residents is approximately 10%. The above ownership breakdown may change depending upon the actual final financial arrangements.

9.4.4.2 Direct Employment

The cumulative direct construction phase and operations phase employment by Solv-Ex is also shown in Table 9.7. The make-up of these employment opportunities and anticipated residence of employees is shown in Table 9.8. The peak construction workforce of 350 will occur in 1996. Staged development will result in a gradual build-up of the operations workforce to an annual level of 349 employees in 1998. The construction workforce will be housed in an on-site camp, while the operations workforce will be divided between the camp (125 person capacity) and residences in Fort McMurray.

[1] Feasibility study, permits, drilling program and environmental monitoring.

[2] Engineering and design, procurement, and construction.

Table 9.8 Regional distribution of Solv-Ex Experimental Project employment, 1995 to 2002.

Item	Fort McMurray Area (%)	Other Alberta (%)	Other Canada (%)	Foreign (%)	Total (%)
Engineering and Design	5	95	0	0	100
Initial Construction	30	60	10	0	100
Operations	100	0	0	0	100

Source: Solv-Ex Corporation (1995)

9.4.5 *Benefit-Cost Analysis*

9.4.5.1 Methodology

Social benefit-cost analysis is a tool for considering the economic efficiency implications and the economic feasibility of a project from an overall societal perspective. The SBCA of the Solv-Ex Project indicates that the Project will yield negative net social benefits to Alberta and Canada; is an economically inefficient use of capital, labour and other inputs vis-a-vis alternative uses for the inputs in the absence of the Project; and yields a social return less than the minimum acceptable to society. This result is to be expected for an "experimental project", where it is difficult to estimate with certainty the outcome, and no recognition is given to the eventual benefits, if the co-production technology is successfully demonstrated.

SBCA is, in principle, an operationalized version of the neo-classical economists' notion of "economic efficiency", in which changes in the economy are judged desirable so long as the aggregate dollar value of beneficial effects exceeds the aggregate dollar value of the costly effects. The difference between the two is the net social benefit. The analysis attempts to quantify each gain and loss to individuals using the principle of willingness of people to pay. That is, what is the dollar amount an individual would be willing to pay to achieve a gain, or what is the dollar amount of compensation required for an individual to willingly live with a loss? In reality, it may not be possible to quantify all the relevant effects, in which case some effects may be considered qualitatively in order to arrive at an overall conclusion respecting desirability.

The conventions of SBCA are well documented. They include taking a broad societal rather than a project sponsor perspective; specification of the base or alternative against which revenue and cost changes are measured; incorporation of externalities and non-marketed effects; adjustments to market prices if they do not reflect opportunity value (i.e., the value of the resources employed in their highest value alternative use); the use of a social discount rate to present value future revenue and cost flows (i.e., the financial capital used in a particular project precludes its use elsewhere in the economy and a corresponding loss of output); exclusion of depreciation and sunk costs; and exclusion from costs of royalties, taxes, and interest paid within the defined jurisdiction.[1]

9.4.5.2 Alberta and Canada Net Social Benefit

The quantified present value estimate of the Alberta net social benefit (NSB) consists of five elements: the benefit of incremental output, less incremental capital and operating costs (excluding property taxes), less federal tax costs, less earning outflows to non-residents, less Project-related public infrastructure costs. The Canada net social benefit is obtained by adjusting the Alberta NSB to include federal taxes (including 15% foreign ownership withholding tax on income from Canada of non-resident persons) and returns on capital paid to other Canadians.

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[1] Useful references on the subject of SBCA include: *Workshop on Benefit-Cost Analysis and Export Impact Assessment*, Sponsored by: National Energy Board and Canadian Energy Research Institute, November 1989, Ottawa: Regulatory Support Office, National Energy Board, 1990; *Workshop on Benefit-Cost Analysis in Energy Economics*, Sponsored by: Canadian Energy Research Institute and National Energy Board, June 1983, Ottawa: Minister of Supply and Services, 1984; and Planning Branch, Treasury Board Secretariat, *Benefit-Cost Analysis Guide*, Ottawa: Information Canada, March 1976.

However, obtaining quantified estimates of the NSB at this time are problematic given that royalties and income taxes are yet to be determined.

No direct Project-related public infrastructure costs are identified. The capital and annual maintenance costs relating to the 17 km extension of Highway 63 north of Fort McKay to the Solv-Ex site are included in the Project's site preparation and maintenance costs. The other elements for which data are available (value of output, and capital and operating costs) are calculated from the annual data underlying Figure 9-10. Future values are discounted to mid-1995 using an 8% real social discount rate to reflect the opportunity cost of capital. The effects are measured over and above the alternative in the absence of the proposed Project.

In summary, the results of the SBCA, based on the data and assumptions provided by Solv-Ex, show that the Project's net social benefit to Alberta and Canada is negative $38.6 million before adjustments for non-resident earnings and tax flows to other jurisdictions. The negative results occur primarily because the substantial front-end capital expenditures are not recovered during the relatively short operating permit term considered (nor is there inclusion of a salvage value adjustment in the terminal year of the analysis). For the overall Project to be positive (and an economically efficient use of Alberta's and Canada's resources, and in the public interest) will require that it proceed to a commercial stage.

In arriving at a decision regarding the overall desirability of the Project from a public interest perspective, the SBCA is the most important of the evaluation approaches. It emphasizes the economic efficiency issue, and can be broadened to include judgments on equity issues (i.e.., the distribution of benefits and costs).

The results are particularly sensitive to the market value of the output, capital expenditures, operating costs, the operating term, and the social discount rate.

9.4.5.3 Other Relevant Factors

Not all relevant effects can be easily quantified, so it is necessary to consider other relevant non-quantifiable factors. The other factors which are identified include:

- potential future benefits from commercial operation of the facilities, assuming success of the Solv-Ex co-production technology (and most capital costs sunk);

- bitumen user cost (opportunity cost of depletion of a natural resource);

- transportation benefits of utilizing current oil pipeline capacity as productive capacity from conventional oil pools decline. The transportation of Solv-Ex crude oil to markets will reduce average transportation costs due to higher pipeline throughput (fixed costs are spread over increased volumes). Reduced average tariffs can potentially result in increased netbacks on existing oil sales volumes;

- possible utilization of otherwise unemployed workers (and hence wages paid by the Project may exceed the value of the foregone output and leisure time);

- skills upgrading of the workforce which may be transferable to other work settings;

- economic diversification of Alberta's economy;

- smoothes adjustments being felt in the conventional oil and gas industry;

- possible cost savings and/or increased output of other projects due to experience gained from this Project;

- contribution to geographically diversified economic growth within Alberta;

- possible economies of scale benefits (e.g., increased supplier profits and/or reduced prices to consumers of the product);

- increased utilization of manufacturing capacity;

- other public infrastructure costs (i.e., duplication of facilities, loss of economies of scale, or higher location costs in more remote regions);

- social and environmental impacts (as examined elsewhere in this EIA);

- contribution to oil supply diversity (oil sands, conventional, and imports);

- security of energy supply benefits, by displacing imports or other domestic output which is then available for export; and,

- distributional effects (i.e., impacts on different groups and individuals in society).

SBCA has practical limitations as the degree of uncertainty concerning eventual benefits and costs of a project increases. This is the case here where no quantification is made of the possible benefits beyond mid-2002. The Experimental Project is to demonstrate technical and economic viability.

9.4.6 *Economic Impact Analysis*

9.4.6.1 Methodology

The economic impact analysis measures the economic activity at the Alberta provincial level stimulated by the Project. The analysis delineates the overall multiplied income (gross output, real gross domestic product, and household income) and employment (person-years) benefits.

The Alberta impacts are derived using general industry input-output multipliers from Alberta Treasury Bureau of Statistics, and include the direct, indirect and induced effects. (Direct effects include the effects on industries from which a project purchases its inputs. The direct employment effect includes a project's on-site labour and the labour component of the direct materials and other inputs. The indirect effects are the impacts on those industries that supply inputs to the industries directly affected, and the effects of supplying those industries for all subsequent rounds of spending. The induced effects are the increase in economic activity generated by the spending of household income created by a project.) The approach is quite different from the SBCA of Section 9.4.5. SBCA deals with the efficiency of resource use, while impact analysis looks at the multiplied effects on factors contributing to the economic well-being of residents and changes in the economy's output and employment levels.

The multipliers used in this section identify the impact of a unit change in the causal factor (e.g., an increase in industry output) upon real gross domestic product[1], gross output[2], and household income[3]. The employment multipliers are expressed in terms of person years of total employment per $10,000 (1984$) change in initial industry output. Hence, the initial impact measured in 1995 dollars must be rebased to constant 1984 dollars, divided by $10,000, and multiplied by the employment multiplier value.

The Alberta multipliers are calculated by the Alberta Bureau of Statistics from the "closed" version of the Alberta input-output model, and include the direct, indirect, and induced effects.[4]

The absolute forms of the total multipliers (with leakages) for GDP, gross output, and household income published for the "construction industry" are applied to total initial capital expenditures for the Project, and the "petroleum and gas wells industry" multipliers are applied to the initial change in demand (i.e., the total value of incremental plant output). The Alberta employment impacts are

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[1] Gross Domestic Product is the sum of all value added in various sectors of the economy. It is the gross value of production of firms less the purchases of goods and services from other firms. The impacts are measured in terms of GDP at factor cost (that is, GDP is measured as the value of production). GDP at market prices includes indirect taxes and subsidies, and is thus the value of goods and services sold less purchased inputs from other firms.

[2] Gross output is an estimate of the value of sales or shipments and therefore represents the gross value of goods and services. It includes the value of intermediate goods (purchases from other firms) plus payments to factors of production.

[3] Household incomes includes wages, salaries, supplementary labour income, and net income of unincorporated business.

[4] The model is closed with respect to households and therefore includes the effect of increased income by consumers being respent generating further income and industrial output. (Household income which may arise from the payment of interest and dividends or government transfer payments is not included.) Spending of other factor incomes such as rent and business profits, and royalties and tax revenues is also excluded.

measured using the absolute form of the total multipliers (with leakages) for the same two industry groups, applied to the initial value of output increase (expressed in 1984 dollars) and divided by $10,000. The Project's incremental utility purchases (natural gas and electricity) are deleted from the initial demand increase to which the operating phase income multipliers are applied, the assumption being that a market for these Alberta resources would exist even without the Project. The Alberta multipliers are shown in Table 9.9.[1]

The analysis also identifies the multiplied government revenue effects on Alberta. The total direct, indirect, and induced impact on Alberta provincial and local government tax revenue is estimated by applying the current average tax rates calculated from provincial economic accounts data to incremental GDP for the Project.[2] The tax revenue estimates are then adjusted to include Project royalties.

9.4.6.2 Alberta Multiplied Impacts

Applying the multipliers in Table 9.9 to the initial economic effects of the Project shown in Table 9.7 results in the multiplied economic impacts shown in Table 9.10 below.

The Project is also a contributor to government revenue, directly and indirectly. The overall multiplied impact on government revenues in Alberta (excluding royalties) is estimated to equal about 16% of incremental GDP, i.e., 16% x $535 million (1995 $), or $86 million. There would also be additional incremental direct royalties from the Project to the Alberta Government, but the amount is unknown at this time.

In summary, the economic multiplier analysis is used to determine the economic magnitude of the proposed development, including the direct, indirect, and induced income and employment effects. This analysis shows that the Project will have a substantial positive impact upon income and employment in the Alberta economy, and be a contributor to government revenue, directly and indirectly.

9.4.7 Fort McMurray - Economic and Labour Impacts

Solv-Ex's local benefits approach is comprised of two components. The first is the provision of employment opportunities for local people and for occupationally disadvantaged groups that have traditionally experienced difficulties in obtaining and retaining employment. The second area is the provision of opportunities for local and regional businesses.

The project will benefit many aspects of the regional service industries including construction, transportation, accommodation and food services. During the construction phase, growth will be experienced by businesses in the mining and construction trades, equipment supply, maintenance

[1] The multipliers are published in Alberta Treasury Bureau of Statistics, *Alberta Economic Multipliers*, May 1991, page 20.

[2] Statistics Canada, *Provincial Economic Accounts Annual Estimates 1985-1989*, Catalogue No. 13-213. The tax revenue estimates exclude transfer payments from other levels of government and investment income (including royalties).

Table 9.9 Alberta economic multipliers.

Phase:	GDP at Factor Cost	Gross Output	Household Income	Employment
Construction	0.965	2.748	0.717	0.212
Operations	0.978	1.921	0.313	0.069

Source: Alberta Treasury Bureau of Statistics (1991)

Table 9.10 Solv-Ex Experimental Project Alberta total income and employment impact, 1995 to mid-2002.

Phase:	Millions 1995 $			Person-Years
	GDP at Factor Cost	Gross Output	Household Income	Employment
Construction	163	464	121	3381
Operations	372	730	119	2481
Total	535	1,194	240	5862

Source: Foster Research (1995)

and repair, truck transport and other transport, materials handling, hotel and motel accommodation, and restaurant businesses.

The impact of the Solv-Ex Project on direct employment opportunities is expected to be 500 person-years of construction employment and 2011 person-years of operations employment from 1995 – 2002. It has been estimated that the total of direct, indirect and induced construction employment created in Alberta is 3381 person-years. For operations, direct, indirect and induced employment is estimated to be 2481 person-years. It was also determined that some 30% of the direct construction employment opportunities would occur in the Fort McMurray region, or 150 person-years. Therefore, it is estimated that the total project employment impact on the Alberta economy will amount to 5862 person-years between 1995 and 2000.

Local purchases are expected to include bulk consumables, fasteners and seals, bearings, tools, clothing and safety gear, lumber, parts (machine, auto, electrical, plumbing), computers, paint, steel, painting, etc.. Operations phase service requirements which may offer local contract opportunities include maintenance, rebuilds, road construction, drilling, reclamation, muskeg removal, de-watering, light duty vehicle maintenance, site security, machine shop work, accommodations, bussing, engineering and research. The nature and extent of these purchases will vary over time.

It is clear from the structure of the regional economy, particularly of Fort McMurray itself, that the secondary and tertiary components respond directly to the activity generated in the primary sectors. As a result, the stimulation provided by development will have beneficial implications throughout the region. This section will present both qualitative and quantitative estimates of these benefits.

The study region has long experience with those projects, and the economy has, by and large, already adjusted to them. Some adjustments, which are beneficial in nature (the maximization of local participation in employment and purchasing), are still taking place, and the development is expected to take advantage of, and reinforce this positive trend. This is particularly true of participation by the regional aboriginal population.

The household income benefits expected to flow from development will be substantial and will generally be welcomed by the region, particularly Fort McMurray, which has seen some leveling off of economic growth in recent years. Household income benefits expected to flow from the Solv-Ex Project will be substantial. However, economic benefits derived from short-term construction activity also carry a price tag. Some of these associated costs are infrastructural and social in nature, and these will be discussed in subsequent sections. The economic costs associated with construction "booms" relate primarily to potential labour force dislocation, inflation and the downturn or "bust" which follows construction.

The regional economy is well experienced with the up and down cyclic nature of the oil sands industry and has matured to the point where it can readily adjust to the scale of construction envisaged by Solv-Ex. It is unlikely that over-expansion to meet temporarily elevated demands or speculation of other kinds will be a problem. Likewise, price inflation is not expected due to current excess capacity and the ease of access to competitive markets for most consumer goods. On balance, the risk of these problems should result in only a low level of impact.

The effects of the construction phase on regional household incomes can be estimated as a proportion of the total Alberta impact. The 1987 economic impact assessment of Syncrude's expansion project estimated this proportion to be 18.5% (Nichols Applied Management, 1987). Since the Alberta total for the construction phase was shown earlier to amount to $121 million, the local and regional impact could reach $23 million during the construction phase.

During the operational phase, the effects on agriculture, forestry and the resource harvesting sectors will be similar to those experienced during the construction phase. The effects on the industrial, trade and service sectors have not yet been determined but generally, it is assumed that the project will be beneficial to all sectors of the economy. Fort McMurray, the major center within the region, will receive the major economic benefit from the project's operation.

The project would result in $119 million in expenditures by Solv-Ex on wages and salaries in the Fort McMurray area during the operations and maintenance phase 1995 – 2002. The combined construction and operations incremental regional household income would thus be approximately $142 million.

9.4.8 *Fort McKay - Economic and Labour Impacts*

Fort McKay, because of its proximity to Solv-Ex, will likely experience more employment and income effect from the project than other communities. As was discussed previously in Section 8.3.2, the recent Fort McKay "Current Labour Force Survey" (April 1995) shows that Fort McKay residents have considerable interest (64 people) in obtaining additional oil sands employment. However, of the 29 people identifying themselves as oil sands workers, only one is currently unemployed. This suggests both that trained/experienced workers can obtain work and a strong desire by others to obtain relevant training and/or experience so that oil sands jobs are more attainable by the balance of the labour force. In terms of suitability for oil sands employment, the survey identifies people that "have completed or are in progress of completing training programs"; there are 2 heavy equipment operators and 32 people with Grade 12 or equivalency (G.E.D.). The survey also identifies 27 unemployed construction workers and the Solv-Ex project will clearly offer them an opportunity for direct benefit. It may, in fact, be an entry path to oil sands operations/maintenance jobs as well.

The Fort McKay Group of Companies is also interested in the longer term business opportunities which will be generated by the Solv-Ex Project. They have identified a number of potential areas as matching their capabilities and interest. The community survey also lists all the businesses in the community along with their capabilities and experience. Much of this capability appears directly relevant to the Solv-Ex project and should provide the basis for participation.

The complete Fort McKay community survey is included as Appendix IX.

It is recommended that Solv-Ex develop a project briefing/information package that focuses on their short and long term plans and the implications for local, regional and Aboriginal employment and business as a component of project socio-economic action plans. In fact, discussions with regional Aboriginal people are already underway with the objective of facilitating the delivery of such benefits.

The development of the project will impede trapping on the lease area because of construction activities. Trapping will likely cease during this phase and the registered trapline lease holders will be compensated for their loss of opportunities.

9.4.9 *Fort Chipewyan - Economic and Labour Impacts*

Fort Chipewyan residents have some potential employment prospects during the construction phase. Fort Chipewyan should experience beneficial impacts through wage employment income earned by its residents and spent in the community.

9.5 Regional Infrastructure and Transport

The physical infrastructure of the study area is judged to be capable of handling the increased services and personnel requirements. The people of the region have had the experience of previous oil sands developments and the Solv-Ex Project is, in local terms, very small in comparison to Suncor and Syncrude.

Solv-Ex plans to house the construction workforce in a permanent camp on the lease. The majority of the operational workforce will be accommodated in the camp and Fort McMurray and transported on a daily basis to the plant site by bus. The plant site is located 85 km north of Fort McMurray on Highway 63.

9.5.1 *Fort McMurray - Infrastructure and Transport Impacts*

Due to the existing community infrastructure, the social, health, recreational and commercial services in Fort McMurray have sufficient spare capacity to accommodate additional population without major negative impacts on the condition that exists today. Solv-Ex feels that the positive aspects of the City will attract the kind of competent workforce that will ensure a smooth operation for the project. One real concern, in terms of both cost and time, is the commuting distance between Fort McMurray and the project site. During the construction period, Solv-ex will be locating its workforce in a camp located on the lease. The camp will meet normal industry standards for accommodation, recreation, meals and safety.

Impacts on Fort McMurray's infrastructure during the construction phase are considered to be minimal, since most of Solv-Ex's construction force will be located in a self-contained camp and because of the sophisticated level of most regional and local services.

Existing regional outdoor recreational facilities are presently meeting the needs of the population. Further minor increases in population will marginally affect the existing facilities. It is important to emphasize use of land for recreation purposes. There are some areas of great aesthetic quality which do not have high capability for intensive use.

Solv-Ex intends to review transportation needs for people, equipment and materials during the construction phase of its project. Rail and road access to Fort McMurray from Edmonton will be assessed, as will the adequacy of air passenger schedules. Highway usage north of Fort

McMurray will need to be reviewed with other operators in the area as well as with government departments. Current projections suggest that project related traffic during construction will amount to 200 vehicles per day. As was shown previously in Table 5.19, this represents a 250% increase in the Average Annual Daily Traffic beyond the Fort McKay turnoff. However, in comparison to existing traffic levels on other portions of Highway #63, it still represents a relatively low utilization of the road capacity.

On balance, out assessment is that the infrastructure of local communities, including Fort McMurray will not be significantly impacted by the construction phase.

Although Solv-Ex plans to locate some members of its operational workforce within the City of Fort McMurray, the operations phase impacts on the region's infrastructure are expected to be minimal.

The issue of the effects of the Solv-Ex Project on transportation has two main impacts on the City of Fort McMurray: arterial roadway links and Solv-Ex traffic on Highway #63 and related public safety and social issues.

On the first matter, while demographic projections show no population thresholds for road infrastructure as being exceeded, and these thresholds were verified by city planners, the City has identified roadway development needs in their Lower Townsite Redevelopment Plan. (RMC, 1991) These needs are related, almost exclusively, to connections between city streets and Highway 63 as well as the Loop Road. The Solv-Ex Project will likely stimulate increased heavy traffic on Highway 63 through the City during both the construction phase and the experimental operations phase. The former increase in volume will amount to only 200 vehicles, a 6% increase in the Average Annual Daily Traffic based on the 1992/3 data for the Fort McMurray to Suncor segment of Highway #63; while the latter is projected to represent only a 7% increase (234 vehicles).

There is also an issue of public safety related to the number of vehicles and the condition of Highway 63 from Fort McMurray to Fort McKay. This issue is also addressed elsewhere with respect to the impact on policing.

The other concern is related to Solv-Ex traffic through the City to the plant site in relation to the truck export of bitumen and other products. One of the main concerns is the high sulphur content of the bitumen that will be trucked to terminal facilities outside the study area. Average annual daily traffic (AADT) between Fort McMurray and the Fort McKay turn-off was reported by Alberta Transportation to total 185 vehicles in 1992/93.

Given that heavy truck traffic represents a particular public safety concern and that the anticipated increase would be noticeable, the impact of this activity is judged to be moderate. However, the City is also concerned about logging truck traffic, reportedly in the order of 250-300 trucks per day, related to the ALPAC project (pers comm. - S. Clark). It is clear that as and when these traffic levels are realized a specific mitigation program will need to be developed. It is recommended that Solv-Ex monitor the development of the City's plans and cooperate in the development and implementation of suitable mitigation with respect to their traffic.

9.5.2 *Fort McKay - Infrastructure and Transport Impacts*

Solv-Ex plans to house the construction workforce in a permanent camp on the lease, located 30 km north of Fort McKay. The majority of the operational workforce will be accommodated in the camp. Fort McMurray and other regional residents will be transported for their shift rotation to the plant site by bus. It is recommended that bussing be provided on a daily basis from Fort McKay to the plant site through both construction and operations phases to facilitate maximum local employment.

Impacts on Fort McKay's infrastructure during the construction phase are considered to be minimal, since most of Solv-Ex's construction force will be located in a self-contained camp.

There is also an issue of public safety related to the number of vehicles and the condition of Highway 63 from Fort McMurray to Fort McKay. This issue is also addressed elsewhere with respect to the impact on policing.

9.5.3 *Fort Chipewyan - Infrastructure and Transport Impacts*

The fact that Solv-Ex plans to house the construction workforce in a permanent camp on the lease, located 30 km north of Fort McKay indicates that there is unlikely to be any impact on Fort Chipewyan's infrastructure.

There is a long-standing debate between the community and the provincial and federal government's concerning the possible upgrading of Highway 63 to all-weather road status from Fort Chipewyan to Fort McKay. The Solv-Ex Project will provide some upgrading from Fort McKay to the lease site but there are no plans to upgrade the highway from the plant site northward.

9.6 Regional Education

This section will identify, by education system component, what the possible impacts of the Solv-Ex Project will be on Fort McMurray and region. As impacts on the education system are primarily demographically-driven, no clear distinction can be made between those which pertain to construction activity and those which are the result of longer-term operations. The nature of the demographic impact of the project suggests that school age populations will remain almost constant over the forecast period. The impact on the regional education system should be very low and limited to program optimization and staffing adjustments in response to actual enrollments.

In view of their growth record, Keyano College is actively planning for their instructional programme needs into the 1990s and beyond. Consistent with this initiative, the College produced an institutional development plan, which provides programming directions through to the year 2000, and a Long Range Campus Development Plan which identifies facility and campus development needs related to those directions. (RMC 1992)

9.6.1 *Fort McMurray - Education Impacts*

It is both the Catholic and the Public Boards' opinion that the rationalization of existing facilities and programs could accommodate any anticipated growth in student enrollment without any changes or expansions. On balance, it is expected that the impact of the Solv-Ex Project on the Fort McMurray Public and Catholic School Boards will be neutral.

A number of factors combine to make projection of impact on an advanced education institution such as Keyano College much more complex than for the school systems. However, it is AEE's judgment that the impact on Keyano College will be low. If anything, the project will provide additional impetus for Keyano's current development plans. The College is well experienced with Syncrude's and Suncor's training needs, has a comprehensive development plan in place, and therefore, will be capable of adjusting any needs the Solv-Ex Project might present in a relatively short period of time.

In light of the foregoing findings with respect to the impact of the project, it is our view that specific mitigation recommendation are unnecessary. Several relevant planning initiatives are already underway which should enable the education system to fully adjust to the various impact scenarios.

9.6.2 *Fort McKay - Education Impacts*

The "Needs Assessments" studies undertaken with the specific objective of providing input to previous oil sands development proposals provide a good base from which to evaluate the possible impacts of the Solv-Ex Project on Fort McKay's educational needs. The recommendations identified deserve careful attention by relevant officials/funding agencies as reflections of community planning and development priorities. The results of the demographic and infrastructure analyses suggest that the specific impact of the Solv-Ex Project on Fort McKay's educational needs is not viewed as substantive.

As it is expected that there will be little or no increase in the population of Fort McKay directly due to the project's construction and operations, and since the existing school facility is operating at less than capacity, demands on the Fort McKay School are considered to be neutral (pers. comm. Tim Bilou). As a result, no project-related impact mitigation measures are considered necessary. However, Solv-Ex should continue to liaise with the community regarding education programming and objectives. Any initiative which addresses existing needs would benefit both community residents and regional employers.

9.6.3 *Fort Chipewyan - Education Impacts*

It is expected that there will be little or no increase in the population of Fort Chipewyan due to the project's construction and operations, and since existing school facilities are operating at less than capacity, demands on the Fort Chipewyan School system are considered to be neutral (pers. comm. Tim Bilou). As a result, no project-related impact mitigation measures are considered necessary..

9.7 Regional Health, Social and Cultural Issues

Socio-cultural issues include family and community organizations, lifestyle expectations, conformity and deviancy, dependency, physical and mental health and, finally, community integration.

Based on earlier assessments of the impact of previous oil sands development proposals, and on the fact that Fort McMurray is now a well-established stable community of 35 000 people, the socio-cultural impacts on the communities are projected to be minimal.

The impacts on the public health of the project's direct operations, i.e., emissions and physical risks/activities, are expected to be low for the following reasons:

- The remote location of the Solv-Ex facilities (30 km north of Fort McKay, 85 km north of Fort McMurray and 220 km south of Fort Chipewyan);
- There are no residents in the vicinity;
- Low air emissions that will meet AEP guidelines (Section 5.2);
- All facilities will be designed to meet the ERCB Noise Control Directive; and,
- All chemicals will be transported according to Transportation of Dangerous Goods requirements.

The plant designs and contingency plans that will be put in place to protect public safety are further described in Section 2.4. Potential physical and mental health impacts related to worker behaviour or indirect project effects are discussed below by community.

9.7.1 *Fort McMurray - Health and Socio-Cultural Impacts*

Fort McMurray, as a result of the Syncrude and Suncor experience over the last several years, is now better prepared to handle rapid change situations than they were with the initial Syncrude project over twenty years ago. The level of community services and facilities are generally equal to or greater than any other Alberta municipality of similar size.

It is expected that some adjustment will occur with new comers reacting to the situation of long work hours and fairly long commuting time between the community and the plant. However, experience has shown that the adjustment has been made by Suncor and Syncrude employees. Also, the level of the City's amenities is such that no major problems are anticipated.

It seems likely that ethnic diversity will continue to increase in Fort McMurray, with gradually rising numbers of Asian and other New Canadians. No cultural or ethnic conflict is expected, however, since there has been none in the recent past, and since the efforts of the Multicultural Association are proving to be effective.

To the extent that increased numbers of people decide to leave the community — and it seems likely that increased numbers of teenagers lacking employment and of retirees may do so if the future prospects for the city are dim — feelings of insecurity and pessimism among Fort McMurray residents will tend to increase. If there are indications of increased oil sands development, such as the current Solv-Ex, Suncor and Syncrude development proposals, or of other significant development activity, feelings of optimism and of increased faith in the future of the community will grow.

It is apparent that the main issues in respect to families in Fort McMurray are parenting and supervision of children by some couples who are overworked, finding adequate day care and after school care for children of working parents, provision of adequate programs and services for adolescents. Note that the situation of adolescents has also been exacerbated by the elevated unemployment, which has left many of them jobless and with too much time on their hands.

The construction workforce will be provided with recreational facilities in the camp at the site. They will be working long hours while there, with little availability of casual/private transportation, and when their work period is complete, they will tend to return directly to their home communities as quickly as possible. Those who do spend time in the City will not normally be seeking to compete with residents for public recreation facilities/programs. Rather, they will tend to seek private sector activity (bars, restaurants, etc.). On balance, construction phase impacts on recreation are expected to be low.

During the construction phase, a variety of social and health impacts must be expected. The incidence of prostitution may increase, and this would likely induce an increase in sexually transmitted diseases, resulting in part from sexual contacts between construction workers and local residents. Teenage girls would be particularly at risk during this period.

Generally, the incidence of sexually transmitted diseases, and those requiring hospitalization has declined in the Northern Lights Health Services Unit (formerly Fort McMurray Health Region) over the past 10 years. The implications of these declines, together with the fact that the city has well equipped and staffed health service facilities justifies the conclusion that the Solv-Ex Project will have no more than low impacts on physical health conditions in the area (pers. comm. Ellen McGladdery).

This analysis suggests that there will be a low to moderate increase in demands on health services in Fort McMurray during the construction phase. Mitigation of this increase will require no increase in the existing physical facilities.

The construction phase will no doubt cause some boom-related stresses in the community. Many, however, will welcome the increase in prosperity and the sense of excitement associated with a construction boom. Thus, the potential adverse effects on community morale and mental health will be mitigated to some extent by positive consequences of the construction phase.

The impacts of the early operations phase years on mental health conditions will be no more than low overall, and will soon decline to neutral.

It is possible that during the construction phase there could be some increase in income dependency, but this probability is slight. It could happen if economic conditions elsewhere in Canada were so depressed that significantly more job-hunters were attracted than were needed, who then became dependent on social assistance (pers. comm. Colleen Spezowka). It is unlikely that either the construction or the operations phases of the Solv-Ex Project will have any adverse effects on income support in Fort McMurray.

9.7.2 *Fort McMurray - Substance Abuse Impacts*

The Solv-Ex Project is expected to have no significant impact on alcohol and drug consumption on Fort McMurray. Rather than bringing a significant increase in cash flow in the community it will tend only to arrest what would otherwise be a longer period of decline. Thus, it will not bring the increased wealth which might result in increased substance abuse. Indeed, there is the possibility, if some of the offence statistics have been elevated by pessimism and insecurity feelings in the community, that the tendency toward reversal of these feelings which the Solv-Ex Project might effect, will be associated with a decline in insecurity-escape drinking.

The increase in the level of earnings in Fort McMurray, and the increase in the numbers of construction workers in the community, will mean an increased potential for inebriation and other substance abuse problems in the community. This may have three sets of consequences:

- It may result in some increase in bar fights and personal injuries.
- Some increase in alcohol impaired driving must be expected, and given an increase in vehicular traffic, there will likely be an increase in motor vehicle accidents, probably exacerbated by increased impaired driving.
- Usage of other drugs will almost certainly increase as well, with the result that there will probably be an increase in drug over-dosed patients.

All of these will contribute to some increase in demands on emergency and other hospital services. This increase may be further elevated by the occurrence of more industrial accidents, but Solv-Ex will have facilities for dealing with minor injuries at the construction site. Serious injuries may be evacuated directly to Edmonton by air.

Mitigation of this impact should include:

- Providing a controlled source of alcohol at the Solv-Ex construction camp, to make it unnecessary for workers wanting alcohol at the end of their work day to travel into Fort McMurray or other communities.

- Efforts should be made to screen out construction workers with histories of substance abuse (who thus may pose a safety threat to themselves and others). This may well prove to be impossible, but there should certainly be a policy to watch for workers who are alcohol or drug-impaired when they come to work at the beginning of their shift, and to discharge those who do so.

- Increase the level of police efforts to apprehend "drug pushers" and persons who are alcohol or drug- impaired.

- Increase the effectiveness of alcohol and drug education programs in the local school systems, so as to try to "inoculate" an increased number of students against the temptation to make increased use of alcohol and drugs when these are increasingly available to them.

We believe that conscientious and consistent application of these mitigative measures from the onset of the construction phase will reduce the impacts to near- low levels.

The operations phase will have no more than a low impact on substance abuse in Fort McMurray. Only among new workers who respond to the relatively high wages they find in Fort McMurray, may there be a tendency toward elevated levels of alcohol and drug consumption. However, the impact of their consumption patterns is expected to be low.

9.7.3 *Fort McKay - Health and Socio-Cultural Impacts*

The Fort McKay community has existed for almost a full generation in proximity to the Suncor and Syncrude plants. During this time it has experienced, and has had to adapt, to a broad range of cultural and other impacts, and has done so quite successfully. None of the Solv-Ex developments which are under consideration here have the potential for inducing additional significant changes in the culture of the community, beyond the current process.

Fort McKay has much greater exposure and experience with urban-industrial culture because it is less isolated than Fort Chipewyan. The greater employment opportunities in support industries, may lead Fort McKay residents to relocate to Fort McMurray. It is anticipated, however, that this will be minimal as the close proximity of Fort McKay to the Solv-Ex plant gives it many advantages in terms of commuting time when compared to Fort McMurray.

The prospects are not so clear cut in respect to construction phase impacts. The location of a permanent construction camp about 25 km from Fort McKay may make the people of this community vulnerable to contacts with "curious" construction workers. Such incursions, resulting in intimidation of some community residents, did occur during construction of the Syncrude plant in the early 1970s. Clearly the community is much better organized and integrated now than it was at that time. Thus, the probability of such incidents may be reduced, but it is basically incalculable, and the possibility of such incidents during a future construction phase cannot be dismissed. When planning for construction of the proposed Solv-Ex project begins, it is recommended that the company consult with leaders of the community in order to plan for appropriate safeguards, if the community is interested in participating in such a process.

The Solv-Ex Project is projected to have low to moderate health impacts on Fort McKay residents (pers. comm. Ellen McGladdery). There will be increased employment of Fort McKay residents, the level of disposable income in the community will increase, and one consequence may be increased alcohol and other drug consumption in the community. As a result, some increase in injuries resulting from consequent substance abuse carelessness or violence, might be expected (pers. comm. S/Sgt. Rick Samotej).

These health problems are expected to be of no more than moderate magnitude, because the community already enjoys a rather high level of income and a further increase is not likely to have significant consequences. Mitigation efforts should largely be based on community perceptions, concerns and initiative. If the community is receptive, Solv-Ex representatives should discuss possible problem consequences with the community, should elicit community reactions as to the nature and magnitude of problems to be expected, and, if the community wants this, should assist in designing appropriate mitigative measures.

The Solv-Ex Project is expected to result in a moderate increase in substance abuse in Fort McKay owing to higher levels of local disposable incomes during both the construction and the operations phases. If the number of locals involved is lower, so that it is only those having substantial experience with industrial employment and the high wages this may bring who obtain construction employment, the impacts will be lower. On the other hand, if there is an abundance of employment, so that immature young people and those with long-standing substance abuse problems are able to earn high construction wages, the impacts in the community could be greater. If many people in extended families and in the community as a whole are working long hours, and become over-tired, shorter-tempered, and if needed chores and community support activities were being ignored or ill-performed, these circumstances would add to community tensions and would increase and broaden the motivation for substance abuse.

If the residents are amenable, there should be community meetings focusing on the substance abuse problems that would certainly increase during the construction phase, on what the consequences of these problems for the lives of many community residents would be, and what actions the community could take to prevent or minimize these problems. The Tribal Administration and relevant Solv-Ex, Provincial government and Indian Affairs officials should lend all possible assistance to the organization of such meetings, but the major initiative for them must come from the community.

The process just described is certainly the most important of the mitigative measures, but in addition the four listed in the preceding discussion for Fort McMurray will help to mitigate the impacts on Fort McKay, as well.

9.7.4 *Fort Chipewyan - Health and Socio-Cultural Impacts*

It is not expected that Solv-Ex's construction and operational phases will have any significant impacts on the socio-cultural patterns in Fort Chipewyan.

The Solv-Ex Project will have little or no impact on any sectors of the population served by the Fort Chipewyan Nursing Station (pers. comm. Ellen McGladdery).

Fort Chipewyan's long distance from the Solv-Ex plant site and from Fort McMurray, as well, buffers them from the impacts resulting from proximity. Such impacts as will be experienced will result from employment of some residents of these communities during construction. These impacts are expected to be no more than low to moderate in magnitude, because the proportions of community residents likely to respond to the distant work opportunities are expected to be small. Moreover, all of these communities have had prior experience of such employment.

The appropriate mitigative efforts are the same as were suggested for Fort McKay: the initiative should be largely in the hands of the Aboriginal community. Solv-Ex representatives should indicate their interest in discussing the possible problems with the community residents, but only at the communities' option or request.

No significant adverse impacts on dependency rates are projected for Fort Chipewyan during the construction or operations phases of the Solv-Ex Project.

The community is expected to experience low impacts on substance abuse as a result of the Solv-Ex Project. Clearly, the magnitude of the impacts will be a function of the amount of construction related employment and disposable income that is generated by the project. If the number is relatively small and is composed of mature and dependable workers who have had earlier experience with the substantial income that construction employment provides, the impacts would be low (pers. comm. Insp. Jim Colson). On the other hand, if a large number of immature young people and of people with persistent histories of substance abuse should find very remunerative construction-related employment, the impacts on these communities could be higher.

The appropriate mitigative measures are the same as were discussed in connection with Fort McKay: efforts to interest community residents in clearly anticipating what substance abuse problems will probably develop during the construction phase, what the consequences of these problems will be for the community and its component groupings, and what the community would be able to do to forestall or to minimize these problems.

9.8 Regional Law Enforcement

9.8.1 *Fort McMurray - Law Enforcement Impacts*

There is no reason to expect that the Solv-Ex Project will result in significant increases in any category of crime, and thus in the workload of the police. With the onset of the construction phase the workload of the police would likely increase resulting in a moderate impact. The increase would cover a broad spectrum. Increased per capita alcohol and other drug consumption would require increased police activity, as well as leading to increased traffic accidents. Increased vehicular traffic in the city and weekend vehicular traffic on the highway to Edmonton would also increase accidents adding to police burdens (pers. comm. Insp. Jim Colson).

9.8.2 *Fort McKay - Law Enforcement Impacts*

The fact that illegal behavior in these communities is commonly associated with alcohol-induced inebriation, means that there is some reason to anticipate that the Solv-Ex Project will result in elevated offence rates associated with increased levels of local employment and disposable incomes. As indicated earlier, larger numbers of residents from Fort McKay will obtain well-paying employment during the construction and operations phases, and as a result there will likely be increased abuse of alcohol and other drugs. This, in turn, could lead to elevated rates of offences against persons and property, illegal possession, traffic violations, etc. (pers. comm. S/Sgt. Rick Samotej). The level of these impacts would likely be of moderate magnitude.

The most effective resources for successful mitigation of these impacts lie with the Aboriginal community. If the community wants to reduce the incidence of these disruptive offences, they could participate in community wide workshops discussing the kinds of problems which will very likely emerge and what the community could do to prevent them. Clearly, concerted community efforts to prevent these problems will be far more effective than the efforts of any outside agency. Relevant Tribal Council, Solv-Ex, provincial government and Indian Affairs officials should cooperatively plan how communities might be interested in carefully exploring self-initiated preventive efforts, and in helping those which are interested to plan for effective interventions, where such help is welcome.

If these communities do not organize themselves for preventive measures, the other source of mitigation is increased police surveillance. It seems likely, however that, because of other pressures and demands, the increased surveillance will not result in the presence of the police at the time when personal or property offences are being committed. Thus they will tend to have little success in deterring such behavior, and their mitigative efforts will be only slightly effective.

9.8.3 *Fort Chipewyan - Law Enforcement Impacts*

There are no reasons to anticipate any adverse impacts for the community of Fort Chipewyan resulting from the Solv-Ex Project. The construction phase will likely result in a relatively small number of workers from the community obtaining construction-related employment. The result of the increased cash flow in the community could result in a parallel increase in offences, resulting in low levels of adverse impacts (pers. comm. Insp. Jim Colson).

The most successful mitigative efforts would emerge from the awareness of impending risk, the concern, the planning and the determination of the community to prevent the kinds of disruption which might be associated with the increase in disposable income. Fort Chipewyan community leaders, Solv-Ex, Provincial Government, and Indian Affairs officials should seek to catalyze this kind of a community response, as described previously. In the absence of this process, only increased police attention can be counted on to limit adverse effects. This is achievable in Fort Chipewyan, where there is a local detachment.

The operations phase of the Solv-Ex Project will not be associated with significant adverse impacts on law enforcement.

9.9 Socio-Economic Action Plans

The purpose of this section is to present in summary form the mitigative measure recommendations which, if implemented, will facilitate the management of the socio-economic impacts of the project. The process of impact management is an iterative one throughout the life of the project. In this manner, these plans will also serve as "contingency plans" to enable Solv-Ex and other key stakeholders to respond to changing socio-economic circumstances. It should be emphasized that there are very real limits in the extent to which Solv-Ex can influence the socio-economic variables which are the subjects of these plans. The formula which leads to good impact management involves parties other than the proponent. To ensure optimum benefits and minimum costs there must be a recognition and acceptance of the responsibility by Solv-Ex, all levels of governments, and especially area residents to cooperatively work toward this goal.

All of these parties can influence the success, or lack thereof, of these plans. These plans should be viewed, therefore, not just as an indication of what Solv-Ex proposes to do but also as a focus for cooperative action by all parties that want to see the most beneficial and least disruptive results possible. Solv-Ex is hopeful that these plans will stimulate discussion of the issues among interested parties resulting in a positive contribution towards impact management.

Solv-Ex is committed to constructing and operating this Project in such a manner as to protect the environment, limit socio-economic disruption and maximize local benefits. To meet this commitment, Solv-Ex should work closely with governments, local communities and other appropriate interest groups in project planning, construction, and operations and maintenance activities. The Project should ensure that its contractors conform to these action plans as they pertain to activities of the contractors on the land used in connection with construction and operation.

9.9.1 *Community Information and Consultation Action Plan*

Solv-Ex, in a role which is appropriate with respect to their on-going relationship with key stakeholders, especially local residents, and their responsibility to manage the overall project, has assumed primary responsibility for developing and implementing the community consultation component of the program. This program will be instrumental in mitigating all anticipated socio-economic effects of the project, both limiting impacts and enhancing benefits. It will assist Solv-Ex, governments and local residents to agree on priority impact management objectives and to cooperate in achieving them.

Public consultation implies that in a process of communication with the communities there is an opportunity for the general public to learn about the project, provide input to its development and influence change by becoming directly involved. Public consultation means public involvement designed to meet the following objectives:

- To enable the public to understand the project so they can anticipate and prepare for project involvement by seeking employment or business opportunities.

- To provide an opportunity for maximum involvement of the communities in project development and operations.

- To provide a communications mechanism for information on specific local business opportunities.

- To solicit opinions on problem areas, current operations and future plans in order to incorporate this input into company plans and policies.

- To obtain advice on community concerns, potential impacts and mitigative measures.

- To acquaint the public with the proponent's socio-economic and environmental plans and policies.

- To coordinate project activities with community related planning.

Solv-Ex recognizes the importance of making project-related information available to all interested parties on a timely basis. Solv-Ex is developing information programs to inform governments, local community bodies, area residents and other interested groups about all aspects of the project that are likely to be of interest or concern to them. These programs will be developed in consultation with the aforementioned parties.

Solv-Ex will work closely with governments, local community agencies and other appropriate parties to ensure that the potential benefits of the project at the community level are fully realized and that potentially adverse effects are avoided, reduced or mitigated wherever possible. In particular, consultations with communities will endeavour to ensure that project activities or facilities will not damage important renewable resources or preclude their alternate use.

It should be noted that a very important element of the consultation process will be the discussion of the relationship of project plans to alternate resource and land use. Solv-Ex's approach places emphasis on preventing potential conflicts. The Environmental Protection Plan will sensitize planned project activities to renewable resource concerns. People in the project area will be continually informed, and their input sought, on the nature, location and timing of project activity and the results of this process will be incorporated in project decision making.

Solv-Ex's consultation program consists of several initiatives which will be on-going throughout the pre-approval stage of preparing this Application to allow for full discussion of key issues and resolution of as many as possible. Solv-Ex's primary consultation focus is on the local population centres of Fort McKay and the City of Fort McMurray. Specifically with the community of Fort McKay, discussions included the tabling of a series of "Principles of Effective Consultation Between the Community of Fort McKay and Solv-Ex Corporation." These principles outline the importance of open communication and cooperation between the two groups to help build a strong working relationship and foster good neighborly relations. The "Principles of Effective Consultation" are included as Appendix X.

Discussions have also been held with individuals and groups in Fort Chipewyan. Solv-Ex recently opened a Fort McMurray Community Liaison Office managed by a long-time local oil sands employee. A record of consultations undertaken to date with respect to this EIA, the results and future plans are detailed in Section 3.0 - Public Consultation and Participation.

9.9.2 *Employment and Training Action Plan*

9.9.2.1 Construction Phase

It is recommended that Solv-Ex work closely with governments and contractors to promote regional employment opportunities in positions which will develop and utilize those skills most readily applicable to the widest range of employment opportunities in the regional labour market.

The plan should address:

- The development of information to identify project related labour requirements, existing and projected labour supply and any resulting imbalances.

- The importance of maintaining an effective public information and consultation program related to this topic.

- A monitoring system, to evaluate the effectiveness of regional manpower delivery to the Project the results of which will be reported to the appropriate government agency if required.

To achieve these objectives, the Solv-Ex should ensure that:

- The Project compile a detailed manpower demand schedule describing to the fullest possible extent, the entrance qualifications and job descriptions for all employment opportunities associated with the project.

- Specific opportunities for training and technology transfer are identified and contractors required to implement construction worker skills enhancement programs.

- All construction workers are required to participate in a pre-employment orientation course prior to beginning work on the project. This course should outline Project policies and applicable government regulations, including those pertaining to environmental and socio-economic matters (and the penalties associated with non-compliance), safety regulations, practices and procedures and material on basic aspects of working in a cross-cultural situation.

9.9.2.2 Operations Phase

Solv-Ex will develop a permanent regional workforce of qualified and trained personnel to provide safe, reliable and efficient operation of the Project. This plan will assist interested regional residents to obtain the maximum long term employment benefits associated with the project.

To achieve these goals it is recommended that Solv-Ex:

- Ensure that regional residents will receive preferential opportunities for permanent employment.

- Provide appropriate orientation briefing to all interested training candidates and career counseling services as part of its training program.

- Provide appropriate orientation to its supervisory personnel responsible for training regional residents.

- Compile job descriptions and associated training requirements as part of its Information and Consultation Program. The timely presentation of this information to communities and government agencies will assist both groups in scheduling their respective participation in upgrading and vocational training courses which may be needed to meet the specified proficiency levels required by the Project.

9.9.3 *Business Opportunities Action Plan*

Solv-Ex is committed to ensure maximum regional participation in the construction and operations of the Project. The construction and the operations of the Project will provide a number of local business opportunities. Solv-Ex will make every effort to support local and regional business development, particularly where the businesses can be sustained following completion of the construction phase.

To encourage regional business to participate, the following activities are recommended:

- Development and implementation of a plan which will ensure that the local business community will receive a preference when bidding on work associated with the Project. This plan will provide for identification of potential business opportunities, information on tendering procedures and establishment and maintenance of a regional bidders list.

- Development of effective communications between the proponents and regional enterprises.

Some basic premises are recommended to help ensure that expectations are reached and positive results are achieved with the business opportunities the project will provide; as follows:

- The regional business community should accept their responsibility to take the initiative by vigorously pursuing available opportunities on a competitive basis.

- Solv-Ex should provide technical advice to local contractors with respect to contract details and logistical matters generally.

- All contractors should be required to utilize regional goods, services and labour to the maximum extent possible.

- Maximum regional participation in the project should be encouraged by making information readily available on the planning, construction and operation of the project to regional businesses, communities, and governments.

9.9.4 *Worker Orientation Action Plan*

It is recognized by Solv-Ex that employees who enter unfamiliar environments will require orientation to the project, not only with respect to environmental or socio-economic issues but also with the relevant working procedures and rules to which their work activities will expose them.

The orientation program is the mechanism through which this important information will be passed. It is recommended that Solv-Ex develop and implement appropriate orientation programs for all employees; the general intent being to prepare employees for their work experience and to make them aware of and sensitive to conditions associated with the project. General working procedures and safety rules, camp rules, emergency response and other contingency procedures, health and medical care, recreational activities, environmental and socio-economic terms and conditions should be communicated to the workforce upon taking employment with Solv-Ex or its contractors.

Proper orientation can result in greater worker efficiency, less environmental and community conflict and fewer delays. The program will be fully coordinated with overall project management.

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10.2 Contact List

Bilou, Tim	Superintendent, Northland School Division #16, Fort McMurray
Brechtel, S.	Alberta Fish and Wildlife
Carroll, Sgt. Wayne	Community Relations Officer, RCMP, G-Division, Edmonton
Clarke, Stephen C.	Community Planner, City of Fort McMurray
Colson, Insp. J.L. (Jim)	Officer-in-Charge, RCMP, Fort McMurray
Ehrentraut, G.	Woodlands Manager, Northlands Forest Products Ltd.
Gervais, Mike	Environmental Health Officer, Alberta Health, Fort McMurray
Heck, Jerry	Superintendent of Schools, Fort McMurray Catholic Schools

Hrapko, J.	Curator of Vascular Plants, Provincial Museum
Ladouceur, Peter	Economic Development Manager, Fort McKay First Nation
Lepine, Rita	Economic Development Officer, Athabasca Chipewyan First Nation, Fort Chipewyan
McGladdery, Ellen	Community Health Nurse, Fort McMurray and District Health Unit, Fort McMurray
Meyer, Bruce	Senior Account Executive, Statistics Canada, Edmonton
Nichols, Beverly	Royal Tyrell Museum, Drumheller
Nichols, Robert G.	Director, Labour Market Research, Alberta Career Development and Employment, Edmonton
Parrish, Doug	Economic Development Planner, City of Fort McMurray
Pope, Don	Planning Forester, Alberta Pacific
Samotej, Staff Sgt. Rick	Operations NCO, RCMP, Fort McMurray
Seidl, Doreen	Administrative Asst., Fort McMurray Hospital, Fort McMurray
Seifried, Dr. Anke	EA Coordinator, Alberta Environmental Protection, Edmonton
Shipley, Ken	Consultant, Shipley Management Services, Fort McMurray
Spezowka, Colleen	Employment Counsellor, Employment and Immigration Canada, Fort McMurray
Veldman, Wim	Hydroconsult EN3 Services Ltd.
Villebrun, Margaret	Administrator, Municipality of Wood Buffalo, Fort Chipewyan
Waddell, John	Superintendent, Fort McMurray Public Schools
Ward, B.	Regional Director, Alberta Forest Service
Wood, Dean D.	Vice-President, Instruction, Keyano College, Fort McMurray

APPENDIX I. Legal Description of the Local Study Area (Lease 5 and Corridor)

I.1 Legal Description of Lease 5

- Section 19; W1/2 Section 29, Section 30; Section 31; W1/2 Section 32; all within Township 96, Range 10, West of the 4th Meridian.
- Pts. LS 1, 8, 9, 16, Section 23; Section 24; E1/2 Section 25; LS 3, 6, 11, 14 and Pts. LS 4, 5, 12, 13 Section 25; E1/2 Section 36; LS 3, 6 and Pts. LS 4, 5, 11, 12, 14, Section 36; all within Township 96, Range 11, West of the 4th Meridian.
- W1/2 Section 5; Section 6; all within Township 97, Range 10, West of the 4th Meridian.
- SE1/4 Section 1; LS 9, 16 and Pts. LS 3, 6, 10, 11, 15 of Section 1; all within Township 97, Range 11, West of the 4th Meridian.

I.2 Legal Description of the Corridor

- LS 14, 15, 16, and Pts. LS 13, Section 31; LS 13, Section 32; all within Township 94, Range 10, West of the 4th Meridian.
- LS 3, 4, 5, 6, 12, 13, 14 and Pts. LS 2, 7, 11, 15, Section 5; Pts. LS 1, 8, 9, 16, Section 6; Pts. LS 1, 8, 9, 16, Section 7; W1/2 Section 8, LS 15 and Pts. LS 2, 7, 10, 16, Section 8; SW1/4 Section 17; LS 2, 7, 11, 12, 13 and Pts. 1, 8, 10, 14, 15, Section 17; NE1/4 Section 18; LS 1, 7, 8, 14 and Pts. LS 2, 6, 11, 13, Section 18; LS 1, 2, 3, 5, 6, 7, 11, 12, 13 and Pts. LS 4, 8, 10, 14, 15, Section 19; Pts. LS 3, 4, Section 20; LS 4 and Pts. LS 3, 5, 12, Section 30; all within Township 95, Range 10, West of the 4th Meridian.
- LS 9, 15, 16 and Pts. LS 1, 7, 8, 10, 11, 14, Section 24; SE1/4 Section 25; LS 9, 10, 14, 15 and Pts. LS 3, 6, 11, 12, 13, 16, Section 25; Pt. LS 16 Section 35; LS 2, 3, 6, 7, 10, 11, 14 and Pts. LS 1, 4, 5, 8, 9, 12, 13, 15, 16, Section 36; all within Township 95, Range 11, West of the 4th Meridian.
- W1/2 Section 1; Pts. LS 2, 7, 10, 15, Section 1; Pts. LS 1, 8, 9, 15, 16, Section 2; LS 8, 9, 16 and Pts. LS 2, 7, 10, 15, Section 11; LS 4, 5, 12, 13 and Pts. LS 3, 6, 11, 14, Section 12; LS 4, 5, 12, 13 and Pts. LS 3, 6, 11, 14, Section 13; LS 1, 8, 9, 16 and Pts. LS 2, 7, 10, 15, Section 14; all within Township 96, Range 11, West of the 4th Meridian.

APPENDIX II. Summary of Public Information Program

Name of Company, Association or Public Interest Group	Name of Contact Person	Date of Contact (day/month)	Presented and Discussed Project Information
Ft. McKay First Nation Band	Melvin Grandjamb, Chief Peter Ladouceur, Environmental Coordinator Cindy McDonald	4/1	PDD[a] discussion meeting
	Peter Ladouceur	10/1	Request for PDD presentation on 1/2.
	Peter Ladouceur	16/1	Presentation agenda for 1/2.
	Peter Ladouceur	18/1, 30/1, 31/1	Confirmations of 1/2 presentation.
	Peter Ladouceur	1/2	Presentation which was voice taped.
	Peter Ladouceur	13/2	Band has written to Federal Government and will review/respond to PTR[b] for EIA.
	Peter Ladouceur	23/2	Lease 5 tour and PDD/PTR discussions.
	Peter Ladouceur	7/3, 13/3, 15/3	Meetings and discussions with First Nations.
	Peter Ladouceur and Ken Shipley	27/3	• Fort McKay Principles of Effective Consultation between the Community of Fort McKay and Solv-Ex. • Review of Corporation Fort McKay's written response to Terms of Reference. • Review of Table of Contents for Report to be prepared for Solv-Ex on traditional resource use/historic resources in Study Areas and Socio-Economic Information.
	Peter Ladouceur	7/4	Budget and scope for EIA input.
Ft. McKay Metis Association	Roger Faichney, President	16/1, 17/1	PDD request/delivery.
	Roger Faichney, President	23/2	Lease 5 tour and PDD/PTR discussions.
Ft. McKay First Nation Band/The Tri-Am Group Inc. (Management Consulting Co.)	Peter Ladouceur, Band Env. Coordinator Ken Shipley, Tri-Am	15/3, 18/3, 19/3, 23/3, 27/3, 3/4, 4/4, 6/4	Meetings and phone discussions to discuss PTR and Band's feedback and, Band/Tri-Am EIA work input on wildlife/other resources and socio-economic development opportunities.
Ft. McKay Trappers Association	Fred McDonald	17/1	PDD request.

(a) PDD: Public Disclosure Document
(b) PTR: Proposed Terms of Reference

APPENDIX II. Continued

Name of Company, Association or Public Interest Group	Name of Contact Person	Date of Contact (day/month)	Presented and Discussed Project Information
Trapper on Lease 5	Ian Faichney, Trapper	16/1	PDD request.
	Ian Faichney, Trapper	12/2	Phone discussion regarding his trap lines.
	Ian Faichney, Trapper	13/2	Ft. McKay meeting with Indian band and ALPAC[c] representative. Meeting with IF.
	Ian Faichney, Trapper	22/2	Trapping map returned to IF.
	Ian Faichney, Trapper	23/2	Lease 5 tour and PDD/PTR discussions.
	Ian Faichney, Trapper	21/3	Provided aerial photo of planned drilling locations.
Trapper on border of Lease 5	Roger Bouchier, Trapper	20/2, 22/2	Phone inquiry regarding meeting in Ft. McKay.
	Roger Bouchier, Trapper	23/2	Meeting.
	Roger Bouchier, Trapper	21/3	Provided aerial photo of planned drilling locations.
Northern Alberta Aboriginal Business Association (NAABA)	Dave Tuccaro, President	4/1	PDD delivered.
	Dave Tuccaro, President	25/1	Presentation to 20 NAABA[d] and ATC members.
Athabasca Tribal Corporation (ATC)	Tony Punko and John Parkins	4/1	PDD discussion meeting.
	Tony Punko and John Parkins	11/1	Request for presentation on 25/1.
	Tony Punko and John Parkins	13/1	Presentation agenda for 25/1.
	Fred Black, Member	17/1	PDD request.
		25/1	20 people, including NAABA members attend presentation.
		30/1	Presentation notes issued.
Ft. McMurray Trappers Association	Jim Rogers, President	4/1, 10/1, 12/2	PDD request and phone discussion.
	Joe Gauthier, Member	13/1, 21/1	PDD discussion meeting.
Ft. McMurray First Nation Band	Bernice Cree, Chief	12/1	PDD delivery.
	Bernice Cree, Chief	21/2	Phone discussion re: PDD and PTR.
Ft. McMurray Metis Association	Grant Golosky, President	21/1	PDD and PTR delivery and meeting.
Fort Chipewyan First Nation Band	Tony Mecredi & Archie Waquan, Chiefs	16/1, 20/1, 22/1	PDD delivery and 18/1 planned meeting.
		31/1	Presentation to 9 band and metis members.
	Archie Waquan	13/2	General phone discussion.

(c) ALPAC: Alberta Pacific Forest Industries
(d) NAABA: Northern Alberta Aboriginal Business Association

APPENDIX II. Continued

Name of Company, Association or Public Interest Group	Name of Contact Person	Date of Contact (day/month)	Presented and Discussed Project Information
Fort Chipewyan Metis Association	Sonny Flett, Chief	16/1	PDD delivery and 20/1 planned meeting.
	Sonny Flett, Chief	20/1	Meeting with SF and ANDC[(e)] members.
	Sonny Flett, Chief	30/1	SF cannot attend 30/1 presentation.
Anzac Metis Association	Sol Lacaille, President	21/1	PDD and PTR delivery.
Janvier Metis Association	Edgar Tatum, President	21/1	PDD and PTR delivery.
Janvier First Nation Band	Fred Black, Chief	13/2	FB commended project after review of PDD and PTR.
Couklin Metis Association	Edward Abby, President	21/1	PDD delivery.
Ft. McMurray Today (newspaper)	Patrick Nicol	10/1	Feedback on SOLV-EX activities.
	Patrick Nicol	13/1, 19/1, 20/1	Draft Public Notice.
	Patrick Nicol	23/1	Public Notice with reference to PTR in this and three other newspapers.
The Windspeaker (newspaper)	Joanne	20/1	Public Notice.
The Native News (newspaper)	Curt Johnson	20/1	Public Notice.
Slave River Journal (newspaper)		20/1	Public Notice.
Arctic College, Renewable Resources Technology Program, Fort Smith	Jack Van Camp, Chairperson	13/2	PDD and PTR request.
Rocky Mountain EcoSystem	Mike Sayer	17/1	PDD request.
Northern River Basin Study	Betty Collicot	17/1	PDD request.
Alberta Environmental Network	George Newton, Office Manager Sam Gunsch, Prov. Coordinator	17/1	PDD request.
Ft. McMurray Environmental Network	Pat McInnes	6/1, 9/1, 16/1	PDD request and delivery.
	Pat McInnes	20/1	Request for phone number of Rob McIntosh.
	Pat McInnes	22/1	Request for PTR for EIA.
	Pat McInnes	2/2	Request for additional PDD and PTR copies.
	Pat McInnes	3/2	Phone discussion on air pollution.
	Pat McInnes	13/2	General phone discussion.

(e) ANDC: Athabasca Native Development Corporation

APPENDIX II. Concluded

Name of Company, Association or Public Interest Group	Name of Contact Person	Date of Contact (day/month)	Presented and Discussed Project Information
Ft. McMurray Environmental Network, continued	Pat McInnes	20/2	General phone discussion.
	Pat McInnes	31/3	General phone discussion.
	Pat McInnes	18/4, 20/4	Discussions re: RMA[f] and mining plan.
Pembina Institute, Energy Clean Air/Caucasus, Oil Sands Coalition	Dan Smith, Chairman	17/1	PPD request.
	Rob McIntosh	17/1	PPD request.
	Rob McIntosh and Dan Smith	12/4	Solv-Ex discussed corporate and financial issues and environmental benefits of the Co-production Experimental Project. Issues related to the EIA wee discussed.
Ft. McMurray Environmental Group	John Rogers, Past President	16/1	General Info delivery and discussion.
City of Ft. McMurray	Mayor	4/1	PDD meeting.
	Doug Parish and Steve Andres	13/2	Development permits.
Alberta Power	Allan Muller	27/1	Power and generator service.
Syncrude	Ray B. Hansen, Lawyer	1/2	PDD and PTR presentation.
Alberta Pacific Forest Industries		13/2	Meeting with Ft. McKay Band member and Lease 5 trapper.
Alberta Energy and Utility Board (AEUB)	Brian Purcell, Head, Mining, Oil Sands John Farnell, Mining, Oil Sands Terry Abel, Head, Process, Oil Sands Frank Segan Marvin Dymtriw	Period February - May 1995	Several meetings regarding application info. requirements of the AEUB.
Alberta Environmental Protection (AEP)	Ralph Dyer, Land Reclamation Division Kem Singh, Air & Water Approvals Division Anke Seifried, Env. Assessment Division Tim Janzie, Env. Assessment Division Chris Hale, Land & Forest Services, Ft. McMurray Steven Yeung, Water Resources Division	15/2, 16/2, 13/3, 17/3, 19/3, 20/3, 26/4, 3/5	• Meeting regarding EIA terms of reference and AEPEA[g] application and information requirements. • Drilling on Lease 5. • Final EIA term of reference issued by AEP on 29/3.

[f] RMA: Resource Management Agreement
[g] AEPEA: Alberta Environmental Protection and Enhancement Act

APPENDIX III.

Table III.1 Vegetation species within the plant communities for the Local Study Area.

Plant Species	Climax White Spruce	Aspen	Aspen Jackpine	Climax Black Spruce	Jackpine-Aspen	Climax Jackpine	Jackpine/ Aspen Black Spruce	Aspen/ Jackpine Black Spruce	Blanket Bog	Slope Bog	Bowl Bog	Patterned Fen	String Fen	Aquatic Types	Riparian Types
TREES															
Abies balsamea	X														
Betula papyrifera		X	X			X				X	X				
Larix laricina										X		X	X	X	X
Picea glauca	X	X	X							X					X
Picea mariana	X	X	X	X			X		X	X	X			X	X
Pinus banksiana		X	X				X		X	X	X				
Populus balsamifera	X	X		X						X	X				X
Populus tremuloides		X	X		X		X				X				X
SHRUBS															
Alnus crispa	X	X	X	X		X	X	X					X		X
Alnus tenufolia	X												X		X
Amelanchier alnifolia						X									X
Andromeda polifolia												X	X		
Arctostaphylos rubra									X						
Arctostaphylos uva-ursi		X	X		X	X	X								
Betula glandulosa									X	X	X		X	X	
Betula pumila										X	X				
Cornus stolonifera		X													X
Juniperus communis					X	X									
Kalmia polifolia											X	X	X	X	
Ledum groenlandicum	X			X	X	X	X		X	X	X				
Lonicera caerulea				X											
Lonicera dioica var. glaucescens	X	X													
Lonicera involucrata	X	X													
Potentilla fructicosa				X			X				X			X	X
Prunus virginiana					X	X									
Rhamnus alnifolia										X					X
Ribes hudsonianum	X	X													

Table III.1 Continued.

Plant Species	Climax White Spruce	Aspen	Aspen Jackpine	Climax Black Spruce	Jackpine-Aspen	Climax Jackpine	Jackpine/ Aspen Black Spruce	Aspen/ Jackpine Black Spruce	Blanket Bog	Slope Bog	Bowl Bog	Patterned Fen	String Fen	Aquatic Types	Riparian Types
SHRUBS (Concluded)															
Ribes oxycanthoides	X	X													
Ribes triste	X	X		X											
Rosa acicularis		X	X			X									
Rubus idaeus	X	X													
Salix bebbiana	X														X
Salix exiqua									X						X
Salix lutea	X													X	X
Salix pedicullaris				X					X	X		X			
Salix petiolaris				X						X		X		X	
Salix planifolia				X						X		X	X	X	
Sheperdia canadensis		X	X		X		X								
Symphoricarpus albus		X	X	X											
Vaccinium myrtilloides		X	X		X	X	X		X	X					
Vaccinium vitis-idaea	X		X		X	X	X				X				
Viburnum edule	X	X													
FORBS															
Achillea millefolium					X	X	X								
Agastache foeniculum													X		
Anemone canadensis				X			X	X							
Apocynum androsaemilifolium					X	X									
Aralia nudicaulis	X	X													
Aster conspicuus			X		X										
Calla palustris													X	X	X
Caltha palustris													X	X	X
Campanula rotundifolia	X	X													
Cardamine pensylvanica		X	X												
Chamaedaphne calyclata											X		X	X	
Chenopodium capitatum	X	X													
Chimaphila umbellata			X		X										

Table III.1 Continued.

Plant Species	Climax White Spruce	Aspen	Aspen Jackpine	Climax Black Spruce	Jackpine-Aspen	Climax Jackpine	Jackpine/ Aspen Black Spruce	Aspen/ Jackpine Black Spruce	Blanket Bog	Slope Bog	Bowl Bog	Patterned Fen	String Fen	Aquatic Types	Riparian Types
FORBS (Continued)															
Cornus canadensis	X	X					X								
Delphinium glaucum	X														
Drosera rotundifolia									X						
Empetrum nigrum						X									
Epilobium angustifolium									X			X			
Epilobium ciliatum		X	X												
Epilobium palustre										X			X		X
Equisetum arvense	X	X		X											
Equisetum fluviatile														X	X
Equisetum pratense				X											
Equisetum scirpoides	X			X					X						
Equisetum sylvaticum	X	X													
Erigeron philadelphicus		X	X												
Eriophorum spp.												X	X		
Fragaria virginiana			X		X	X	X								
Galium boreale		X	X		X		X								
Galium trifidum		X	X												
Galium trifolium		X	X												
Geocaulon lividum					X	X									
Geum macrphyllum		X	X						X	X					
Goodyera repens					X		X								
Gymnocarpum dryopteris	X			X											X
Habenaria hyperborea	X			X					X						
Hedysarum boreale		X	X												
Impatiens capensis	X	X											X		X
Lathyrus ochroleucus		X	X		X		X								
Lemna spp.														X	
Lilium philadelphicum var. andinum				X											
Listera borealis		X	X												

Table III.1 Continued.

Plant Species	Climax White Spruce	Aspen	Aspen Jackpine	Climax Black Spruce	Jackpine-Aspen	Climax Jackpine	Jackpine/ Aspen Black Spruce	Aspen/ Jackpine Black Spruce	Blanket Bog	Slope Bog	Bowl Bog	Patterned Fen	String Fen	Aquatic Types	Riparian Types
FORBS (Continued)															
Lycopodium annotinum					X	X									
Maianthemum canadense var. interius		X	X		X	X									
Matteuccia struthiopteris	X														
Mertensia paniculata	X	X													
Mitella nuda	X														
Nuphar variegatum														X	
Orthilia secunda	X		X	X											
Oxycoccus microcarpus									X	X	X				
Parnassia palustris	X														
Petasites sagittatus	X			X											
Plantago major															
Potentilla norvegica													X	X	
Potentialla palustris												X	X	X	X
Potomogetom natans														X	
Pyrola asarifolia	X														
Pyrolay elliptica	X														
Ranunculus lapponicus													X	X	
Rubus chamaemorus									X		X				
Rubus pubescens	X								X						
Rumex occidentalis															X
Sagittaria cuneata														X	
Sarracenia purpurea									X						
Sibbaldia procumbens						X									
Smilicina trifolia	X			X			X	X	X						
Sparganium angustifolium														X	
Spiranthes romanzoffiana									X				X		
Streptosus spp.	X	X													
Thalictrum dasycarpum		X													
Thalictrum occidentale		X													

Table III.1 Continued.

Plant Species	Climax White Spruce	Aspen	Aspen Jackpine	Climax Black Spruce	Jackpine-Aspen	Climax Jackpine	Jackpine/ Aspen Black Spruce	Aspen/ Jackpine Black Spruce	Blanket Bog	Slope Bog	Bowl Bog	Patterned Fen	String Fen	Aquatic Types	Riparian Types
FORBS (Concluded)															
Thalictrum venulosum		X													
Urtica dioica ssp. gracilis															
Vicia americana	X	X	X												X
GRASSES AND GRASSLIKES															
Beckmannia syzigachne													X	X	
Calamagrostis canadensis	X	X	X												
Carex aquatilis											X	X	X		
Carex atherodes										X					
Carex aurea									X	X					
Carex rostrata									X	X	X	X	X		
Deschampsia caespitosa													X	X	X
Elymus innovatus		X	X			X	X								
Juncus spp.														X	
Luzula spp.															
Muhlenbergia glomerata													X		X
Oryzopsis pungens						X				X					
Phragmites communis														X	X
Poa spp.	X	X			X	X									
Schizachne purpurascens		X	X												
Scirpus spp.														X	
Spartina pectinata														X	
Typha latifolia														X	X
MOSSES															
Tomenthypnum nitens	X			X						X					
Drepanocladue spp.									X		X		X		
Hyloconium splendens	X			X					X	X					
Pleurozium schreberi	X			X	X	X	X		X	X	X				
Ptilium crista - castrensis	X			X											
Sphagnum spp.	X			X					X	X	X				

Table III.1 Concluded.

Plant Species	Climax White Spruce	Aspen	Aspen Jackpine	Climax Black Spruce	Jackpine-Aspen	Climax Jackpine	Jackpine/ Aspen Black Spruce	Aspen/ Jackpine Black Spruce	Blanket Bog	Slope Bog	Bowl Bog	Patterned Fen	String Fen	Aquatic Types	Riparian Types
LICHENS															
Cladina spp.		X	X	X	X	X	X		X						
Cladonia spp.				X	X	X			X						
Stereocaulon lividum					X										

APPENDIX IV.

Table IV.1 Vegetation species sensitivity to SO_2 emissions.

Plant Species	Common Name	High Sensitivity	Moderate Sensitivity	Low Sensitivity
TREES				
Abies balsamea	Balsam fir	X(b)	X(c,e)	
Betula papyrifera	Paper birch	X(a,d)		
Larix laricina	Tamarack	X(b,d,e)		
Picea glauca	White spruce		X(c,e)	X(a,b)
Picea mariana	Black spruce			X(e)
Pinus banksiana	Jack pine	X(d)	X(b)	
Populus balsamifera	Balsam poplar	X(a,d)	X(b,e)	
Populus tremuloides	Trembling aspen	X(a,d,e)	X(b)	
SHRUBS				
Alnus crispa	Green alder	X(b)		
Alnus tenufolia	River alder	X(a)	X(d)	
Amelanchier alnifolia	Saskatoon	X(a,d,f)		
Arctostaphylos uva-ursi	Kinnikinnick			X(a)
Betula pumila	Dwarf birch			X(a)
Cornus stolonifera	Red-osier dogwood		X(a,c,d,e)	
Empetrum nigrum	Crowberry	X(f)		
Juniperus communis	Ground juniper			X(c)
Ledum groenlandicum	Labrador tea	X(f,h)		
Lonicera caerulea	Fly honeysuckle	X(a)		
Prunus virginiana	Chokecherry		X(e)	
Ribes hudsonianum	Wildblack currant		X(d)	
Ribes oxycanthoides	Wild gooseberry		X(d)	
Ribes triste	Wild red currant		X(d)	
Rosa acicularis	Prickly rose	X(a)		

Table IV.1 Concluded.

Plant Species	Common Name	High Sensitivity	Moderate Sensitivity	Low Sensitivity
GRASSES AND GRASSLIKES				
Carex aquatilis	Water sedge		X[f,g]	
Carex atherodes	Awned sedge		X[f,g]	
Carex aurea	Golden sedge		X[f,g]	
Carex rostrata	Beaked sedge		X[f,g]	
Elymus innovatus	Hairy wild rye		X[f,g]	
MOSSES				
Tomenthypnum nitens		X[b]		
Drepanocladue spp.		X[b]		
Hyloconium splendens	Stair-step moss	X[b]		
Pleurozium schreberi	Feather moss	X[b]		
Ptilium crista - castrensis	Knight's plume	X[b]		
Sphagnum spp.	Peat moss	X[b]		
LICHENS				
Cladina spp.		X[b]		
Cladonia spp.	Reindeer lichen	X[b]		
Stereocaulon lividum		X[b]		

Sources:
[a] Sandhu *et al.* (1980)
[b] Malhotra and Blauel (1980)
[c] Treshow (1984)
[d] Treshow and Anderson (1989)
[e] Shriner *et al.* (1990)
[f] World Health Organization (1987)
[g] Addison *et al.* (1986)
[h] Addison *et al.* (1984)

Table IV.3 Vegetation species sensitivity to NO_x emissions.

Plant Species	Common Name	High Sensitivity	Moderate Sensitivity	Low Sensitivity
TREES				
Abies balsamea	Balsam fir	x[a]		
Picea glauca	White spruce	x[a]	x[b]	
MOSSES				
Tomenthypnum nitens		x[c]		
Drepanocladue spp.		x[c]		
Hyloconium splendens	Stair-step moss	x[c]		
Pleurozium schreberi	Feather moss	x[c]		
Ptilium crista-castrensis	Knight's plume	x[c]		
Sphagnum spp.	Peat moss	x[c]		
LICHENS				
Cladina spp.		x[c]		
Cladonia spp.	Reindeer lichen	x[c]		
Stereocaulon lividum		x[c]		

Source: (a) Treshow (1984)
(b) Shriner *et al.* (1990)
(c) Malhotra and Blauel (1980)

APPENDIX V Information Report for Solv-Ex Cumulative Effects Study.

INFORMATION REPORT FOR SOLV-EX

CUMULATIVE EFFECTS STUDY

Prepared by

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April 19, 1995

1. INFORMATION ON ENVIRONMENTAL AND HERITAGE RESOURCES

1.1 INTRODUCTION:

SOLV-EX, a U.S. based mining and petroleum company, has made a serious application to mine bitumen in the Bitumount area, north of the community of Fort McKay. The ultimate objective of this operation is to separate and refine aluminum and other materials from the tar sand base, using state-of-the-art technology developed within the company's home operation in New Mexico.

This new development will have a variety of effects on all aspects of the environment in the vicinity of the project. These effects will be both positive and negative, and will impose their influence on the people of Fort McKay and virtually all of the renewable resources utilized by these people as far back as they can remember.

This area and the people within it have already been influenced by the operating presence of two massive tar sands extraction plants. The influx of exploration crews and recreation bound people from Fort McMurray and parts further south, although transient, has measurably altered the lifestyle of the Fort McKay people, and the ecological parameters of the Cumulative Effects Study Area which is the subject of this work.

1.2 GENERAL OBSERVATIONS:

The following information has been derived from a series of interviews of local people, conducted by Mr. Peter Ladouceur, and a publication of Traditional knowledge entitled, "There Is Still Survival Out There."

The information shown on the map accompanying this document lists traplines, cabins, historic sites, burial grounds, and trails. It also includes resource information on the locations of fur bearers, big game, game birds, fish, and various kinds of vegetation, such as the location of tree species and plants of medicinal and spiritual value.

The locations of the items established in earlier times by the Fort McKay people (i.e., cabins, burial grounds, trails, etc.) are reasonably specific and discrepancies between actual ground locations and those to be found on the map can be directly attributable to the author's less than spectacular interpretation of maps produced from the interviews and from observations taken from maps shown in other illustrated documents.

Items on the attached map showing the locations of bird groups, fish, big game and fur bearers, however, can be interpreted as being the location of an area of considerable size, probably anywhere from a few to hundreds of acres. The map should, therefore, be interpreted in this fashion.

1.3 CUMULATIVE EFFECTS STUDY AREA FOR BIOPHYSICAL RESOURCES:

1.3.1 Fur Bearers and Traplines:

The entire CUMULATIVE EFFECTS STUDY AREA impacts on a total of four traplines. On the east side of the Athabasca River, and most seriously impacted by the SOLV-EX mine plan, is Trapline #2137 operated by Ian Faichney. Immediately to the south is Trapline #1650, operated by Raymond Boucher. Across the Athabasca River to the west and adjacent to the Faichney line is Trapline #2016, unoccupied according to the map in the Fort McKay publication. To the immediate south of this unoccupied line is Trapline #2457, operated by Howard Lacorde, and immediately south of Mr. Lacorde is Trapline #0965 operated by James Grandejambe.

A significant amount of the trapline operated by Ian Faichney will be physically influenced by the actual SOLV-EX mine operation. His trapline and the others, however, have already experienced negative influences caused by the much increased volume of human traffic, both ground and air and occasionally on foot, during virtually every month of the year. While habitat destruction has so far been kept to a minimum, the ever increasing sound disturbance levels have had major effects on the distribution of fur bearers. Trappers spend time on their traplines during the entire year and their observations appear to indicate that the number and species composition of fur bearers in these areas has decreased during the past ten years.

According to the trappers, there are several reasons for this precipitous drop in animal numbers. Among the most important of these are:

(a) the drop in fur prices caused by the factless blustering of the Animal Rights and Anti-Fur Activists;
(b) the subsequent reduction of effort on the part of the trappers because of the reduction of fur prices and the added costs to the trapper in fuel and maintenance which he can no longer recuperate due to (a);
(c) superimposed upon the above, the apparent reduction in the number of fur bearing mammals inhabiting the Cumulative Effects Study Area. (Interviews of trappers)

Trappers in other parts of northern Alberta have noticed and recorded adherent movements of fur bearers, such as fisher. These trappers have postulated that the massive amount of clear-cut logging currently ongoing in northern Alberta has forced such movements due to massive habitat alterations.

Traditionally, fur bearers produced from the Cumulative Effects Study Area include the following:

Canines:	Wolf Coyote Fox
Mustelids:	Weasel (Three Species) Wolverine Fisher Marten Otter Mink
Rodents:	Beaver Squirrel Muskrat
Felines:	Lynx
Ursids:	Black Bear*

*NOTE: Historically, the occasional Grizzly was taken in the area. This has not occurred, however, for many decades. Black bears, though mostly transients, are nevertheless still occasionally encountered in the area.

Rabbits (Snow Shoe Hares) occur in the general study area and are taken for fur and meat throughout the year. The numbers taken are to a large extent dependent upon cyclic population levels. Skunks are present but not normally in large numbers. Raccoons are rarely if ever sighted this far north.

The aquatic and semi-aquatic fur bearers, such as mink, otter, muskrat, and beaver, are trapped from late fall to shortly after break-up in the spring. The bulk of the harvest, particularly of muskrat and beaver, generally occurs during the period just prior to freeze-up and immediately after break-up. Both of these species are regarded as much for food as they are for fur. This is particularly true for areas further north.

Wolves and coyotes are taken incidentally throughout the year, but are specifically sought during the winter because of the excellent quality of the hides during that period.

Wolverines and fisher are not prevalent, and it appears from the observations of trappers in the northwestern part of Alberta, that fisher are moving from heavily logged areas to those which still maintain some degree of quality habitat. It should not be surprising, therefore, to experience in the next few years, an increase in fisher numbers within the study area because of the logging and land clearing which is occurring in the surrounding areas.

This phenomenon should not be expected to last, however, and the commencement of mining activities in the study area will undoubtedly have an adverse effect on fisher and very likely a number of other species which currently inhabit the Cumulative Effects Study Area.

OBSERVATIONS AND SUGGESTIONS:

Out of the four traplines which will be impacted by the area, it is likely that only one (Mr. Faichney's) will be physically altered to any great degree by the activity of the SOLV-EX mine. The encroachment of exploration activities and the enhancement and upgrading of access to the mine site and the surrounding area, along with the permanent establishment of pumping stations, power lines, gas and oil wells, seismic operations, etc., will over time have a serious negative influence on the maintenance and operation of these traplines. The lifestyles of the individuals and the families, some of whom have been involved with the same trapline for several generations, have been built around the trapping/hunting/gathering and trapline and trail maintenance which they and generations of their ancestors have carried out.

Efforts must, therefore, be made by both SOLV-EX and the Fort McKay people to ensure that these lifestyles are integrated into the mine operational plan, or options derived which will be acceptable to all parties involved. Discussions to this end should begin as soon as possible with the people of Fort McKay and the trappers themselves.

1.3.2 Big Game Harvest Sites

The following text has been paraphrased from an interview with trapper, Ian Faichney. The interview was conducted by Peter Ladouceur on April 11, 1995.

"Access to the Cumulative Effects Study Area and specifically to the local study area, has up until the past two decades been almost exclusively by boat, mostly for the purposes of hunting moose and/or berry picking. According to the Elders, this area was very productive for both of these resources. The moose population was stable and it was not uncommon to see up to seven moose feeding in the waters of McClelland Lake on any given evening. Moose populations have since declined drastically, and there is no sign that they are returning to their former levels. This is coincident with the construction and opening of the 'Bridge to Nowhere.' At present, the area receives little use from local hunters and gatherers. This is because of the heavy increase in use by transient hunters and campers from further south. This has increased the probability of hunting accidents and unpleasant interactions with these people in the field, according to local hunters."

While both Barren Land and Woodland Caribou have been seen in the area in times past, neither are common. While records do not indicate that buffalo have been harvested in the study area, they have occasionally been harvested in the Tar River area to the north and on the west side of the Athabasca River.

Deer (both mule and white-tailed) are occasionally taken in the Fort McKay area. As in other parts of Alberta, deer have a tendency to appear in areas shortly after the influx of logging and agriculture, or where the boreal forest has been opened by man. It is, therefore, predictable that with the exploration and all of the ancillary activities which accompany the opening of a mine, such as road building and vegetation clearing, deer will become more prevalent in the McKay/SOLV-EX area. Local meat preference is moose, however, and deer will most likely be harvested on an incidental and more opportunistic basis.

A number of salt licks are located within the Cumulative Effects Study Area. At least one salt lick is located within the local study area itself (see map). These should be given some priority because: (a) they are not numerous; and, (b) they provide valuable nutritional minerals to big game animals, particularly after a hard winter. The females are frequent visitors to these salt licks in the period immediately after calving.

All ungulates which are harvested by the people of the Community of Fort McKay are taken for meat, hides, horns, fat, tool-making materials, etc. These include moose, deer, caribou, and buffalo. Black bears, while under most circumstances considered a fur bearer, are hunted as a big game animal for fat and fur from early spring to late fall.

OBSERVATIONS AND SUGGESTIONS:

The opening and operation of a large bitumen mine in the Study Area will have a major influence on the wild ungulate populations of the region. Deer (white-tail, in particular) will likely profit from the opening of the forested areas because of the increased security from four legged predators and a more suitable habitat type. For most of the others, however, the increase in number of humans and the increased pressure on both habitat and the animals themselves, will undoubtedly result in a general reduction of numbers unless specific actions are taken to provide both habitat and security for these animals while they adapt to the new environmental regime.

Intensive elk and buffalo rearing operations should be given serious consideration as joint venture projects. This and other habitat items should be discussed as soon as possible to ensure that the planning of such a project is not rushed, and it is recognized early on in the budgetary process.

1.3.3 Game Bird Harvest

Local hunters have over the decades developed their own categories for the birds they hunt. These have been placed upon the included map in a somewhat generic fashion. All of the birds taken are used for meat, and feathers, both decorative and utilitarian (i.e., feather ticks, pillows, etc.). Parts of certain birds, for example, the pelican, are used for waterproof pouches and bags which are "excellent for carrying tobacco." It should be noted here that the eggs of geese, ducks and gulls are regarded by some of the locals as delicacies and are harvested from the nests of these birds in the spring. (Personal communication: Melvin Grandejambe)

The local categories of birds are as follows*:

Water Birds:	Geese Ducks Loons Pelicans Swans Cranes Gulls
Upland Birds:	Ruffed Grouse Ptarmigan Spruce Grouse Sharp-tailed Grouse
Predators:	Eagles (Bald and Golden) Owls (Great Grey and Great Horned)

*NOTE: There are a whole variety of smaller birds, such as various kinds of black birds and snow birds, which pass through the area and which are generally regarded by the locals as incidental. These birds do not make up any of the harvest.

The harvesting of the above birds and their eggs is by necessity a seasonal activity. The people of the Community of Fort McKay hunt black ducks in the spring on their way north. In the summer, bird hunting is done on a more incidental basis. Ducks and geese nesting locally are taken for food. Their eggs are taken in the early spring immediately after they commence laying.

The real hunting takes place for waterfowl in the fall, however, when the massive fall migrations pass through the Study Area. During this period, ducks, geese, swans and sandhill crane are hunted for meat, feathers, down, etc.

Upland game birds, such as grouse and ptarmigan, are found in the Study Area all year round and are hunted on an incidental basis throughout the year. Ptarmigan migrate through the Study Area from south to north in the spring and back in the fall. They are hunted on their southward migrations from about November to March. At this point in time, they begin the move back north for the summer.

OBSERVATIONS AND SUGGESTIONS:

Certain species of upland game birds and waterfowl respond well to habitat management and enhancement. It should be agreed upon at the earliest convenience of both SOLV-EX and the people of the Community of Fort McKay that certain habitat management and enhancement techniques will be undertaken to ensure, where at all possible, the stabilization or the increase in upland game bird populations for the benefit of not only the people of Fort McKay but for the benefit of the general environment. Sharp-tailed grouse respond well to artificially created dancing grounds under the proper conditions. This species would be a good one to start with because the techniques for habitat enhancement and behavioral manipulation are well documented, relatively inexpensive, and easy to implement.

Waterfowl, particularly Canada Geese, respond dramatically to the creation of secure nesting sites near or on permanent water impoundments. Other waterfowl respond well to the creation and maintenance of good goose habitat.

Fish respond well to permanent water impoundments with shallow areas for food organism productions and deep areas for the maintenance of cool temperatures which are required for optimum metabolic need and oxygen level maintenance.

The people of the Community of Fort McKay are of the opinion that these items should be the subject of discussion at the earliest convenience of SOLV-EX and the Fort McKay Community. This will ensure that decisions will be made in plenty of time to become part of the budget and planning cycle of SOLV-EX, and that these decisions will be satisfactory to all parties.

1.3.4 Fish Harvest Sites

The people of the Community of Fort McKay still depend to some extent on the ability to catch fish in large numbers during certain periods of the year for sustenance. Trappers also catch certain species, such as chubs and ling for food for dogs which some of them still use in the remote areas. Species utilized by the Fort McKay people, in general, are the following:

- Jackfish (Great Northern Pike)
- Whitefish
- Pickerel (Walleye)
- Lake Trout
- Goldeye
- Ling (Burbot, Maria)
- Sucker
- Chub
- Perch

Historically, fish were taken in numbers from the river. This practice has not occurred for many years because of the warnings issued by the Alberta Fish and Wildlife Service to the effect that individuals should ration the amount of Athabasca River fish they eat in a specified period of time because they contain contaminants, such as heavy metals and chlorinated hydrocarbons.

While a certain number of large predatory fish, such as Jackfish, Pickerel and Ling, are still taken from the river and eaten from time to time, the bulk of the fish consumed by the people of Fort McKay are taken from the lakes and tributary streams in the area.

Whitefish and pickerel are most sought after, and along with the char groups (lake trout and brook trout), they are taken during the spring and fall migrations (pickerel in the spring and whitefish and char in the fall).

In the winter, whitefish, pike, lake trout, pickerel, perch and goldeye are caught through the ice. They are also caught in the summer in open water. These fish are consumed by the people of the community. Chubs and ling, generally caught in the river or its tributaries, are used for animal food (i.e., dogs, etc.)

Fish camps are still operated throughout this part of Alberta during periods of open water. They also serve as muskrat trapping centers in the spring. During other periods, they function as meat drying sites and fish preparation stations. They are also social and cultural in nature and serve to enhance community solidarity.

OBSERVATIONS AND SUGGESTIONS:

Fish harvesting within, and in general proximity of, the Cumulative Effects Study Area occurs throughout the year with the exception of the periods during break-up and freeze-up. It is recognized at the outset that within the actual Athabasca River System and the lakes in the general vicinity of the Cumulative Effects Study Area, not much will change for the worse once the mine is in operation. This is not to say that everything is satisfactory with the fishery in the river. It is in reality stating that a great deal of the damage has already been done and with the advent of one more mine on the river system, any additional damage which might be attributed to that mine will be difficult to measure.

That said, some concern must be expressed for spawning areas in those tributary streams to the Athabasca River located in the Cumulative Effects Study Area. It is clear that efforts in the area of water quality maintenance*, and stream rehabilitation and habitat enhancement should be high on the list of environmental priorities for the SOLV-EX Project Group.

*NOTE: The subject of water quality is not addressed in this document. It is, nevertheless, a very important item in the list of environmental concerns which require special attention in the planning and operation of a mine of any kind.

This item, therefore, must be addressed somewhere in the environmental impact assessment for this project to the satisfaction of, not only the people of the Community of Fort McKay, but to all Albertans.

It is the opinion of this study team that Agreements in Principle, and even perhaps a Memorandum of Understanding on this subject, should be reached as soon as possible.

Also to be included in these discussions will be the subject of a commercial fish culture operation which would go a long way in the effort of providing a healthy, pollution-free source of fish protein to the local people and, perhaps even provide jobs and profit to those employed in such an endeavor.

1.3.5 Berry Harvest Sites

Berry harvesting, surprisingly, is carried on throughout the year. The bulk of it, however, occurs from mid-summer to fall. This activity has a serious social aspect to it. The act of berry picking in the Community of Fort McKay is regarded as a family centered activity. In fact, it is common for several families to take part in a berry picking outing. It is truly a community building and fostering activity. As previously stated in the earlier text, several decades ago the only access to the currently described Cumulative Effects Study Area was by boat. The activities which brought the people by boat to the Study Area were moose hunting and berry picking.

There are roughly twenty-five different types of berries to be found within the Study Area. The local people divide these into those that are "sweet" and those that are "bitter." The bitter berries, i.e., juniper, bearberry (kinnikinnick), dogwood (bunch berry), and hazelnut are generally dried and used to make tea.

Tea can, of course, be made from the "sweet" berries as well, but most of these are eaten raw, dried, or cooked.

The following is a list of the types of berries which can be located in the Study Area:

Sweet: Huckleberry
Blueberry
Cranberry (High Bush, Bog, Low Bush)
Saskatoon
Pincherry
Chokecherry
Raspberry (Dwarf, Trailing)
Currant (Red, Black)
Gooseberry
Strawberry
Rose Hips
Twisted Stalk

Bitter: Bearberry (Kinnikinnick)
Dogwood (Bunch Berry)
Juniper Berry
Hazelnut

OBSERVATIONS AND SUGGESTIONS:

The list of berries presented above represents a cross section of habitat types from those of primary successional stages (i.e., raspberry, strawberry, rose hips, etc.) to those found in more advanced successional stages (i.e., juniper berry, bearberry).

In many instances, surficial disturbance is likely to enhance the appearance of vegetation which produces berries. Mother nature appear to favor these species when it comes to the initial invasion of a newly cleared area of the forest.

It is suggested that efforts be made to assist in this re-establishment of vegetation when reclamation is being carried out. It has become clear that standard reclamation practices in this area have suffered numerous losses while the areas being revegetated naturally appear to be doing just fine. Perhaps there is a lesson here for all of us.

This item should be included in the negotiations which have been alluded to in the previous text, and these should begin as soon as possible.

1.3.6 Trees and Plants for Cultural and Medicinal Use

In addition to the berry producing plants identified in the section above which constitute a variety of woody plants, forbs and shrubs, there are a number of other plants which vary in constitutional makeup from very large coniferous and deciduous trees to those which are regarded as emergent vegetation in the wetlands of this part of the country.

These plants have a variety of uses which range from building material to medicinal. The plants listed in the following are all usable in whole or in part as medicines for a variety of ailments and illnesses, the cures for which, over the previous millennia, have been derived by the ancestors of those people now living in communities such as Fort McKay. The list is by no means final and while those plants listed do indeed have uses as medicines, they are by no means to be regarded as the only plants in this area which can be utilized in this fashion.

Trees:	Coniferous	Black Spruce White Spruce Jack Pine Lodge Pole Pine Tamarack Balsam Fir
	Deciduous	Balsam Poplar Aspen Willow Sp. Alder Birch

Other plants which are used locally to treat a variety of ailments are the following:

- Seneca Root
- Rat Root
- Wintergreen
- Mint
- Blueberry Roots (for infusion or tea)

The areas of heavy use for locating these herbal remedies (and trees from which various kinds of materials can be utilized from the bark, the sap and the roots), are the river and tributary corridors, such as the Athabasca River and the Fort McKay River and the other river corridors to the north.

OBSERVATIONS AND SUGGESTIONS:

These areas can be preserved on site or they can be enhanced or created in other areas. It is unlikely many of the locations outside of the Study Area itself will be in any real danger of being destroyed. However, the people of Fort McKay are prepared to commence discussions on this subject along with those previously mentioned as soon as possible to determine what can be done to ensure that such sources of medicinal and herbal remedies can be maintained or enhanced.

2. LOCAL STUDY AREA

2.1 CABINS AND TRAILS

There are six cabins in the Cumulative Effects Study Area. Five of those are on the east side of the Athabasca River and four are located within the local Study Area. These four are owned, from north to south, by Felix Beaver, Pat Shott, Isadore Lacorde, and Louis Tourangeau. Two other cabins are located within the Cumulative Effects Study Area. On the west side of the Athabasca River and just north of the cabin owned by Pat Shott, there is a cabin located at this site, owned by Ernie Lacorde. At the far northern end of the Cumulative Effects Study Area, and on the east side of the river, there is a cabin owned by Edmond Ducharme.

There are a number of trails leading into the areas above the river valley, and a series of trails leading up and down the Athabasca River Valley and into the tributaries on both sides of the river.

It should be noted that virtually all of these trails are hand cut and a number of them are hundreds of years old. There are numerous historic markers and items of historic value located along these trails, and efforts should be made to ensure that these locations are at least recorded and, where possible, preserved for historic and cultural reasons.

2.2 SPIRITUAL, SACRED AND/OR BURIAL SITES

Within the local study area, there are three burial sites. A single grave site is located south of the cabin owned by Pat Shott. Another such site is located close to the cabin owned by Isadore Lacorde, and the last, located just outside of the local Study Area to the south, is a graveyard containing more than forty graves.

Within the actual local Study Area, no historic sites have been recorded at this point in time. Several are located on the periphery of the Study Area, including the old fort site which is recorded as a historic site.

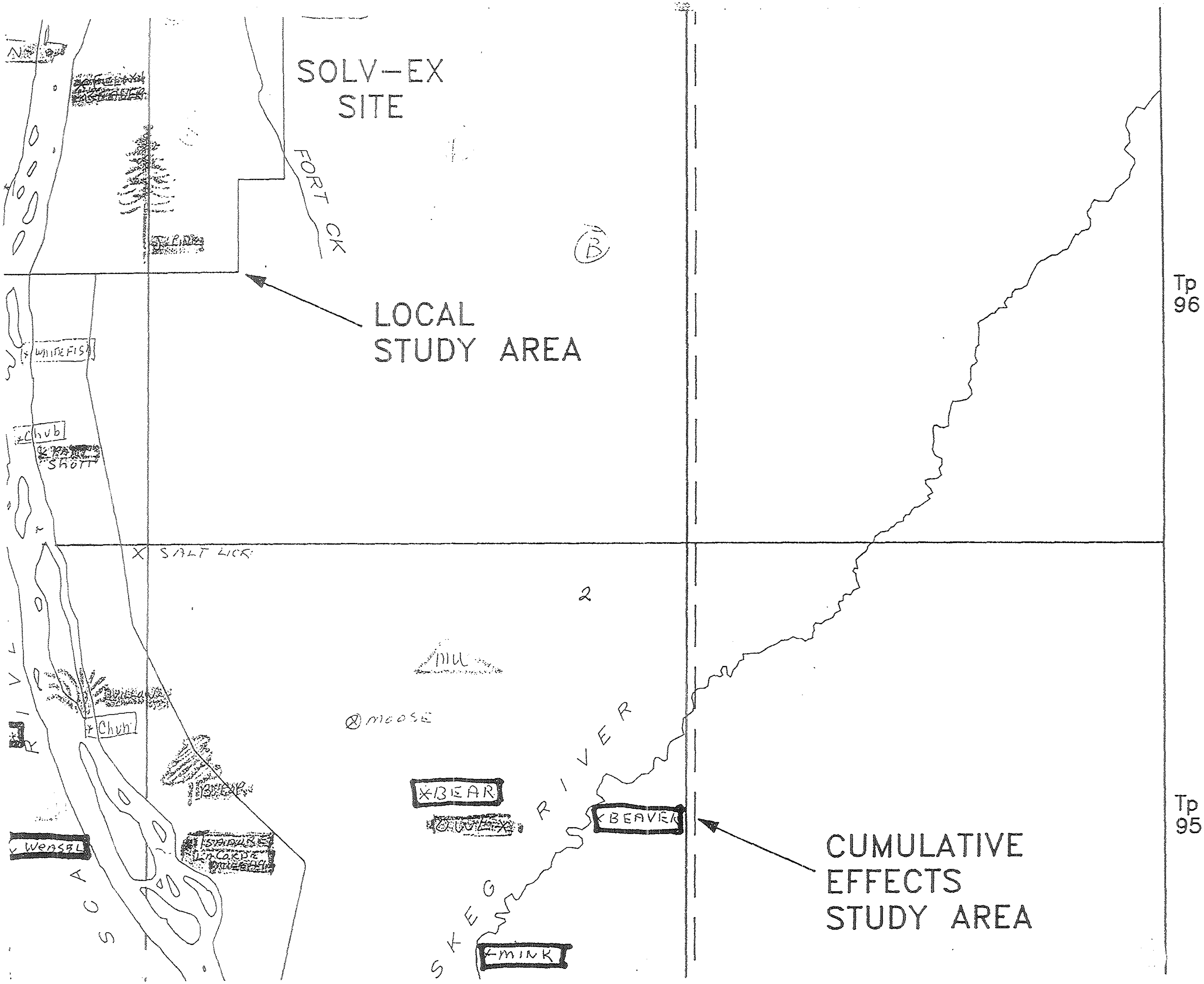
OBSERVATIONS AND SUGGESTIONS:

Efforts must be made to ensure that these sites are treated and maintained with the dignity and respect that they have earned and that they deserve. Desecration or damage to these sites will be regarded with disfavor.

3.0 DISCUSSION AND CONCLUSIONS

The following months will bring SOLV-EX to this area to carry out a variety of studies, ground breaking activities, construction activities, and a whole series of technical and administrative activities which will culminate in the opening and operation of the mine, should this project be approved. The people of Fort McKay are observant, hardworking and want it clearly understood that they wish to be involved in A POSITIVE MANNER FROM THE OUTSET.

The term, "Sustainable Development," has been coined by federal politicians and is bantered about by a variety of bureaucrats in an effort to illustrate that they: (a) have an environmental conscience, and; (b) they understand what it means. The people of the Community of Fort McKay have been practicing "Sustainable Development" for centuries, which is why there are still large amounts of renewable natural resources to be had in this area. It is the intent of the people of Fort McKay to ensure, through cooperative involvement and participation with SOLV-EX, that the status of the level and quality of the renewable resources in this area, is not only maintained, but with any luck and some collective effort, enhanced.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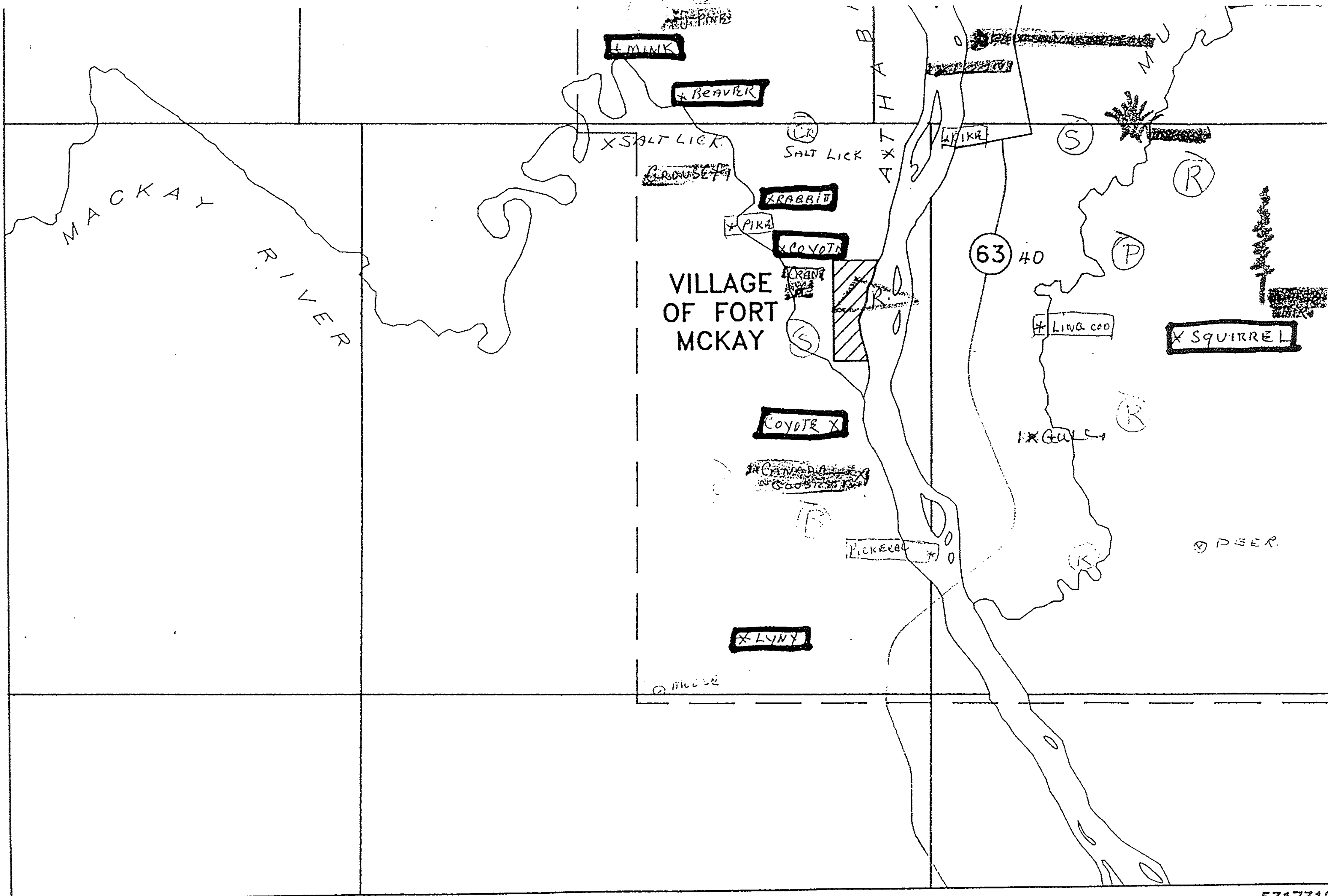
CUMULATIVE
EFFECTS
STUDY AREA



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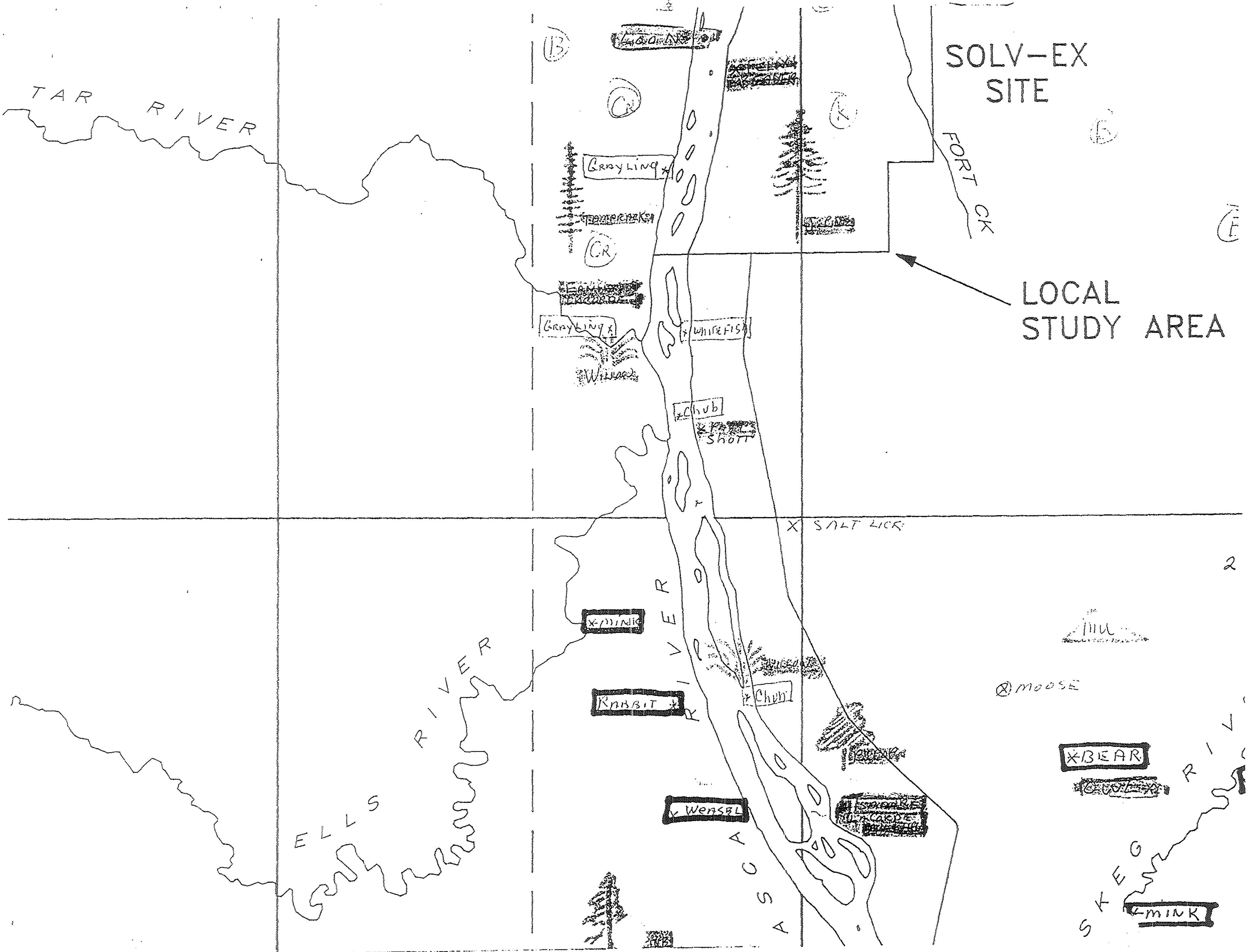
2

CUMULATIVE EFFECTS STUDY AREA


SOLV-EX
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TAR RIVER
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MINK
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Weasel
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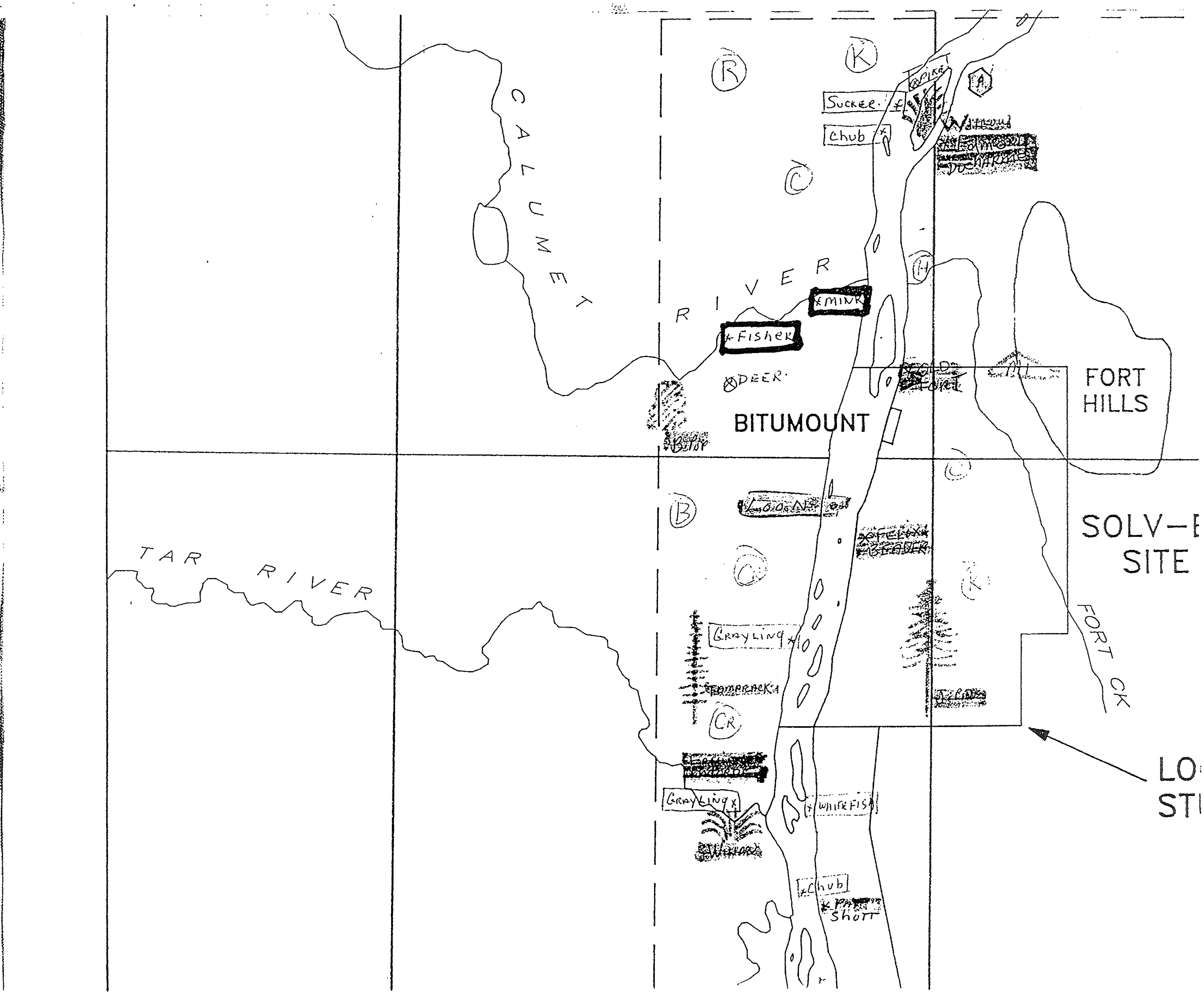
2



CALUMET RIVER
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Whitefish
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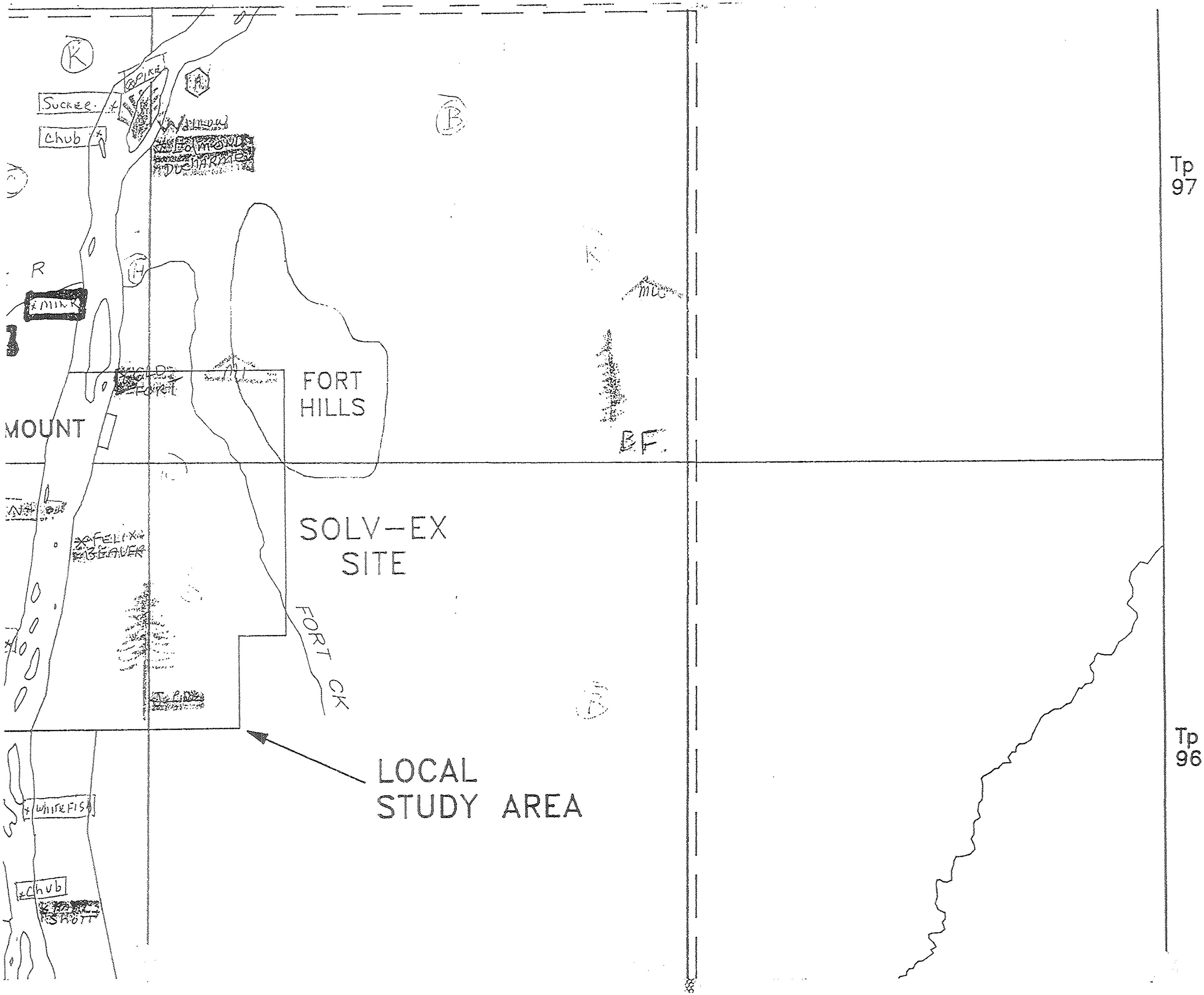
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BEAVER
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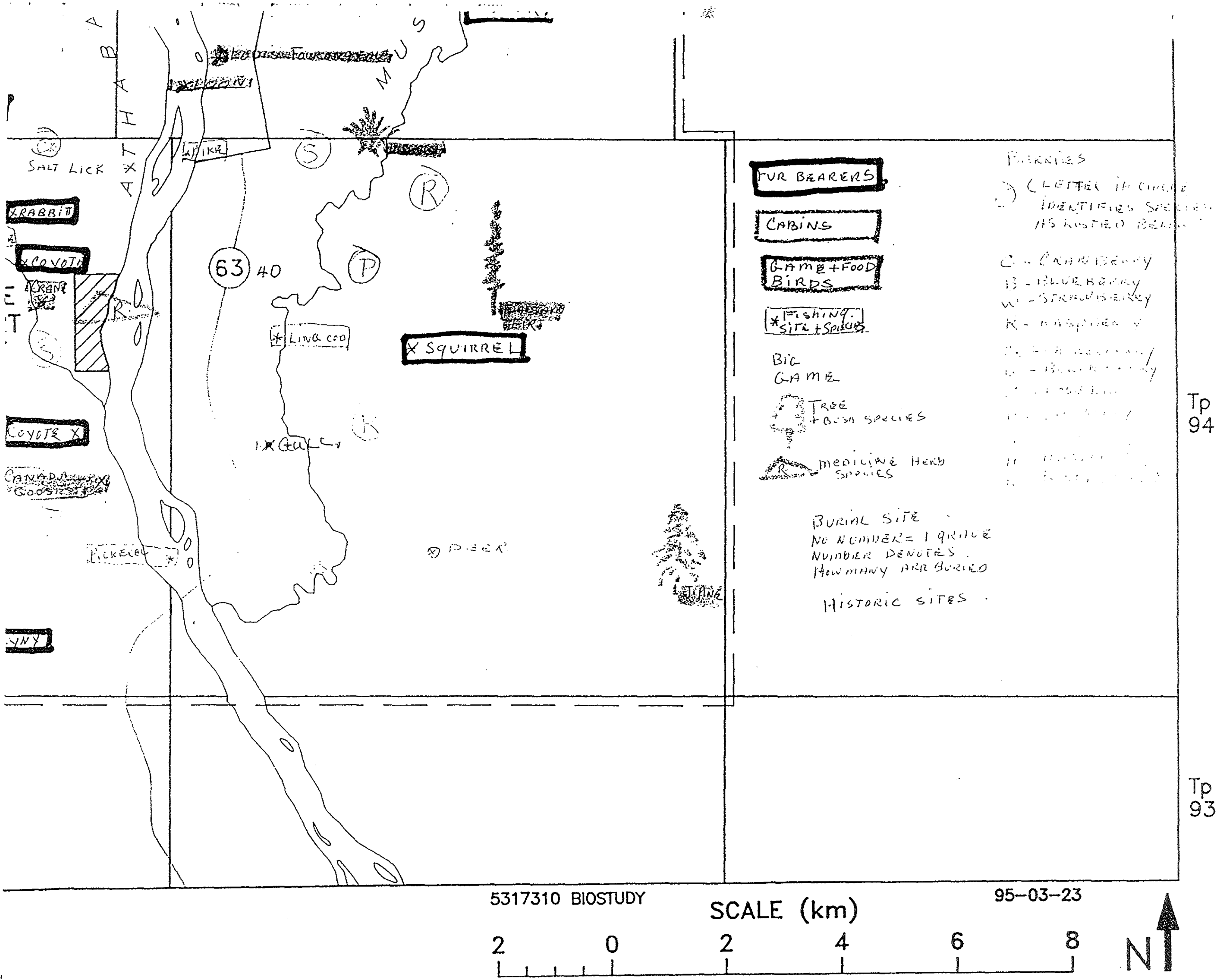

SALT LICK
XRABBIT
XCOYOTE
COYOTE X
CANADA GOOSE
PICKEREL
LING COD
X SQUIRREL
GULL
DEER
PINE
63
40
FUR BEARERS
CABINS
GAME + FOOD BIRDS
FISHING SITE + SPECIES
BIG GAME
TREE + BUSH SPECIES
MEDICINE HERB SPECIES
BURIAL SITE
NO NUMBER = 1 GRAVE
NUMBER DENOTES HOW MANY ARE BURIED
HISTORIC SITES
C - CRANBERRY
B - BLUEBERRY
W - STRAWBERRY
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95-03-23
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APPENDIX VI. Common and scientific names of bird and mammal species expected to occur in the Oil Sand Region.

A. Birds

Common Name	Scientific Name
LOONS (Gaviiformes)	
Common loon	*Gavia immer*
GREBES (Podicipediformes)	
Pied-billed grebe	*Podilymbus podiceps*
Horned grebe	*Podiceps auritus*
Red-necked grebe	*Podiceps grisegena*
PELICANS AND CORMORANTS (Pelecaniformes)	
White pelican	*Pelecanus erythrorhynchos*
Double crested cormorant	*Phalacrocorax auritis*
HERONS AND BITTERNS (Ciconiformes)	
American bittern	*Botaurus lentiginosus*
Great blue heron	*Ardea herodias*
DUCKS, GEESE AND SWANS (Anseriformes)	
Tundra swan	*Cygnus columbianus*
Greater white-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Ross's goose	*Chen rossii*
Canada goose	*Branta canadensis*
Green-winged teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
Northern shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American widgeon	*Anas americana*

APPENDIX VI. Continued.

Common Name	Scientific Name
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Greater scaup	*Ayhya marila*
Lesser scaup	*Ayhya affinis*
Common goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Hooded merganser	*Lophodytes cuculatus*
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Ruddy duck	*Oxyura jamaicensis*
HAWKS, FALCONS AND EAGLES	**(Falconiformes)**
Osprey	*Pandion haliaetus*
Bald eagle	*Haliaeetuus leucocephalus*
Northern harrier	*Circus cyaneus*
Sharp-shinned hawk	*Accipiter striatus*
Golden eagle	*Aquila chrysaetos*
Northern goshawk	*Accipiter gentilis*
Harris' hawk	*Parabuteo unicinctus*
Red-shouldered hawk	*Buteo lineatus*
Broad-winged hawk	*Buteo platypterus*
Swainson's hawk	*Buteo swainsoni*
Red-tailed hawk	*Buteo jamaicensis*
Rough-legged hawk	*Buteo lagopus*
Amercan kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine falcon	*Falco peregrinus*
Gyrfalcon	*Falco rusticolus*
GROUSE, PHEASANTS AND PTARMIGAN	**(Galliformes)**
Spruce grouse	*Dendragapus canadensis*
Willow ptarmigan	*Lagopus lagopus*
Ruffed grouse	*Bonasa umbellus*
Sharp-tailed grouse	*Tympanuchus phasianellus*

APPENDIX VI. **Continued.**

Common Name	Scientific Name
CRANES COOTS AND RAILS (Gruiformes)	
Sora rail	*Porzana carolina*
American coot	*Fulica americana*
Sandhill crane	*Grus canadensis*
Whooping crane	*Grus americana*
SHOREBIRDS (Charadriiformes)	
Black-bellied plover	*Pluvialis squatarola*
Lesser golden plover	*Pluvialis dominica*
Mongolian plover	Charadrius mongolus
Semipalmated plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus*
Greater yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Solitary sandpiper	*Tringa solitaria*
Spotted sandpiper	*Actitis macularia*
Whimbrel	*Numenius phaeopus*
Hudsonian godwit	*Limosa hemastica*
Sanderling	*Calidris alba*
Semipalmated sandpiper	*Calidris pusilla*
Western sandpiper	*Calidris mauri*
Least sandpiper	*Calidris minutilla*
White-rumped sandpiper	*Calidris fuscicollis*
Baird's sandpiper	*Calidris bairdii*
Pectoral sandpiper	*Calidris melanotos*
Short-billed dowitcher	*Limnodromus griseus*
Long-billed dowitcher	*Limnodromus scolopaceus*
Common Snipe	*Capella gallinago*
Wilson's phalarope	*Phalaropus tricolor*
Bonaparte's gull	*Larus philadelphia*
Ring-billed gull	*Larus delawarensis*
Herring gull	*Larus argentatus*
California gull	*Larus califonicus*
Common tern	*Sterna hirundo*
Black tern	*Chlidonias niger*

APPENDIX VI. Continued.

Common Name	Scientific Name
OWLS (Strigiformes)	
Great horned owl	*Bubo virginianus*
Snowy owl	*Nyctea scandiaca*
Northern hawk-owl	*Surnia ulula*
Great gray owl	*Strix nebulosa*
Long-eared owl	*Asio otus*
Short-eared owl	*Asio flammeus*
Boreal owl	*Aegolius funereus*
NIGHTHAWKS (Caprimulgiformes)	
Common nighthawk	*Chordeiles minor*
KINGFISHERS (Coraciiformes)	
Belted kingfisher	*Ceryle alcyon*
WOODPECKERS (Piciformes)	
Yellow bellied sapsucker	*Sphyrapicus varius*
Downy woodpecker	*Picoides pubescens*
Hairy woodpecker	*Picoides villosus*
Northern three-toed woodpecker	*Picoides tridactylus*
Black-backed woodpecker	*Picoides arcticus*
Northern flicker	*Colaptes auratus*
Pileated woodpecker	*Dryocopus pileatus*
PASSERINE BIRDS (Passeriformes)	
Olive-sided flycatcher	*Nuttalornis borealis*
Western wood pewee	*Contopus sordidulus*
Yellow-bellied flycatcher	*Empidonax flaviventris*
Alder flycatcher	*Empidonax alnorum*
Least flycatcher	*Empidonax minimus*
Eastern Kingbird	*Tyrannus tyrannus*
Bank swallow	*Riparia riparia*
Barn swallow	*Hirundo rustica*
Gray jay	*Perisoreus canadensis*
Blue jay	*Cyanocitta cristata*
Black-billed magpie	*Pica pica*
American crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*

APPENDIX VI. Continued.

Common Name	Scientific Name
Black-capped chickadee	*Parus atricapillus*
Boreal chickadee	*Parus hudsonicus*
Red-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia familiaris*
Winter wren	*Troglodytes troglodytes*
Marsh wren	*Cistothorus palustris*
American dipper	*Cinclus mexicanus*
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Regulus calendula*
Veery	*Catharus fuscescens*
Swainsons thrush	*Catharus ustulatus*
Hermit thrush	*Catharus guttatus*
Wood thrush	*Hylocichla mustelina*
American robin	*Turdus migratorius*
Varied thrush	*Ixoreus naevius*
Bohemian waxwing	*Bombycilla garrulus*
Cedar Waxwing	*Bombycilla cedorum*
Solitary vireo	*Vireo solitarius*
Warbling vireo	*Vireo gilvus*
Philadelphia vireo	*Vireo philadelphicus*
Tennessee warbler	*Vermivora peregrina*
Orange-crowned warbler	*Vermivora celata*
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Magnolia warbler	*Dendroica magnolia*
Black-throated green warbler	*Dendroica virens*
Palm warbler	*Dendroica palmarum*
Bay Breasted warbler	*Dedroica castanea*
Blackpoll warbler	*Dendroica striata*
American redstart	*Stenophaga ruticilla*
Ovenbird	*Seiurus aurocapillus*
Northern waterthrush	*Seiuris noveboracensis*
McGillivary's warbler	*Oporornis tolmiei*
Common yellowthroat	*Dendroica coronata*
Canada warbler	*Wilsonia canadensis*
Wilson's warbler	*Wilsonia pusilla*
Western tanager	*Piranga ludoviciana*
Rose-breasted grosbeak	*Pheucticus ludovicianus*

APPENDIX VI. **Continued.**

Common Name	Scientific Name
American tree sparrow	*Spizella arborea*
Chipping sparrow	*Spinzella passerina*
Clay-colored sparrow	*Spinzella pallida*
Savannah sparrow	*Passerculus sandwichensis*
LeConte's sparrow[a]	*Ammospiza leconteii*
Fox Sparrow	*Paserella iliaca*
Song sparrow	*Melospiza melodia*
Lincoln's sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza georgiana*
Dark-eyed junco	*Junco hyemalis*
Lapland longspur	*Calarius lapponicus*
Snow bunting	*Plectrophenax nivalis*
Red-winged blackbird	*Agelaius phoeniceus*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Brewer's blackbird	*Euphagus cyanocephalus*
Common grackle	*Quiscalus quiscula*
Brown-headed cowbird	*Molothrus ater*
Pine Grosbeak	*Pinicola enucleator*
Purple Finch	*Carpodacus purpureus*
Red crossbill	*Loxia curvirostra*
White-winged crossbill	*Loxia leucoptera*
Common Redpoll	*Carduelis flammea*
Hoary redpoll	*Carduelis hornemanni*
Pine siskin	*Carduelis pinus*
Evening grosbeak	*Coccothraustes vespertinus*

[a] Scientific names are based on The American Ornithologists Union (1982). Checklist of North American Birds. With supplementary Updates through to 1989.

APPENDIX VI. **Continued.**

B . Mammals

Common Name	Scientific Name
Masked shrew	*Sorex cinereus*
Dusky shrew	*Sorex monticolus*
Water shrew	*Sorex palustris*
Arctic shrew	*Sorex arcticus*
Pygmy shrew	*Sorex hoyi*
Little brown bat	*Myotis lucifugus*
Northern long-eared bat	*Myotis septentrionalis*
Big brown bat	*Eptesicus fuscus*
Hoary bat	*Lasiurus cinereus*
Snowshoe hare	*Lepus americanus*
Least chipmunk	*Tamius minimus*
Woodchuk	*Marmota monax*
Red squirrel	*Tamiasciurius hudsonicus*
Northern flying squirrel	*Glaucomys sabrinus*
Beaver	*Castor canadensis*
Deer mouse	*Peromyscus maniculatus.*
Red-backed vole	*Clethrionomys gapperi*
Heather vole	*Phenacomys intermedius*
Meadow vole	*Microtus pennsylvanicus*
Muskrat	*Ondatra zibethicus*
Northern bog lemming	*Synaptomys borealis*
Meadow jumping mouse	*Zapus hudsonicus*
Porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Wolf	*Canis lupus*
Arctic fox	*Alopex lagopus*
Red fox	*Vulpes vulpes*
Black bear	*Ursus americanus*

APPENDIX VI. Concluded.

B. Mammals

Common Name	Scientific Name
Marten	*Martes americana*
Fisher	*Martes pennanti*
Ermine	*Mustela erminea*
Least weasel	*Mustela nivalis*
Mink	*Mustela vison*
Wolverine	*Gulo gulo*
Otter	*Lutra canadensis*
Striped skunk	*Mephitis mephitis*
Lynx	*Lynx canadensis*
Mule deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus viginianus*
Moose	*Alces alces*
Caribou	*Rangifer tarandus*

(b) Scientific names are based on Smith, H.C. (1989). A checklist of mammals of Alberta (revised 1989). Natural History Occasional Paper No. 11. Provincial Museum of Alberta. and Smith, H.C. Alberta Mammals: An Atlas and Guide. Provincial Museum of Alberta, Edmonton, Alberta.

APPENDIX VII. Ungulate Aerial Survey and Wildlife Track Survey - Methodology and Results of the March 1995 Inventory of Solv-Ex LSA

VII.1 Ungulate Aerial Survey

An aerial survey of the LSA was conducted on March 29, 1995 (Figure VII.1; Table VII.1). A 206 Jet Ranger helicopter was used to fly 29 transects and a Geographic Positioning System (GPS) was used to locate waypoints along transect (Table VII.1). Transect lines were located 400 m apart with 100% coverage of the 76.4 km^2 area. The aircraft was flown at a height of approximately 100 m and an airspeed of between 60 to 100 km per hour depending on habitat type. The field crew consisted of a navigator and two observers. Sightings of wildlife were recorded on data forms, as well as located on a 1:50 000 topographic map. The following data were recorded for each observation:

- Species
- Number
- Age and Sex (if possible)
- Immediate Habitat Type
- Dominant Habitat Within 50 m of sighting
- Terrain and Aspect

The results of the survey are shown in Table VII.2. Only one moose was seen during the aerial survey, although four sets of fresh moose tracks were observed from the helicopter.

Four beaver lodges were noted along Fort Creek within the area covered by the survey.

I.2 Track Survey

A total of 11 transects were located within the LSA at 6 locations (Habitat Map; Figure VII.1). At each site two sign survey transects, each 500 m long were established perpendicular to the Athabasca River. The transects were either parallel to each other or end on end and were a minimum of 50 m apart.

Along each transect, tracks which intercepted the transect were recorded. This provided information on the total number of track intercepts for each species in a given length of continuous habitat. Tracks which had greater than three separate sets of tracks were considered runs and treated as three animals in all transects. Because of weather constraints all track information was based on one track day of 24 hr duration.

Analysis of track survey results consisted of calculating track intercepts/kilometer for each species within each of the major habitat types. The results give indication of the presence of species within the Study Area as well as the relative use of habitats by wildlife species.

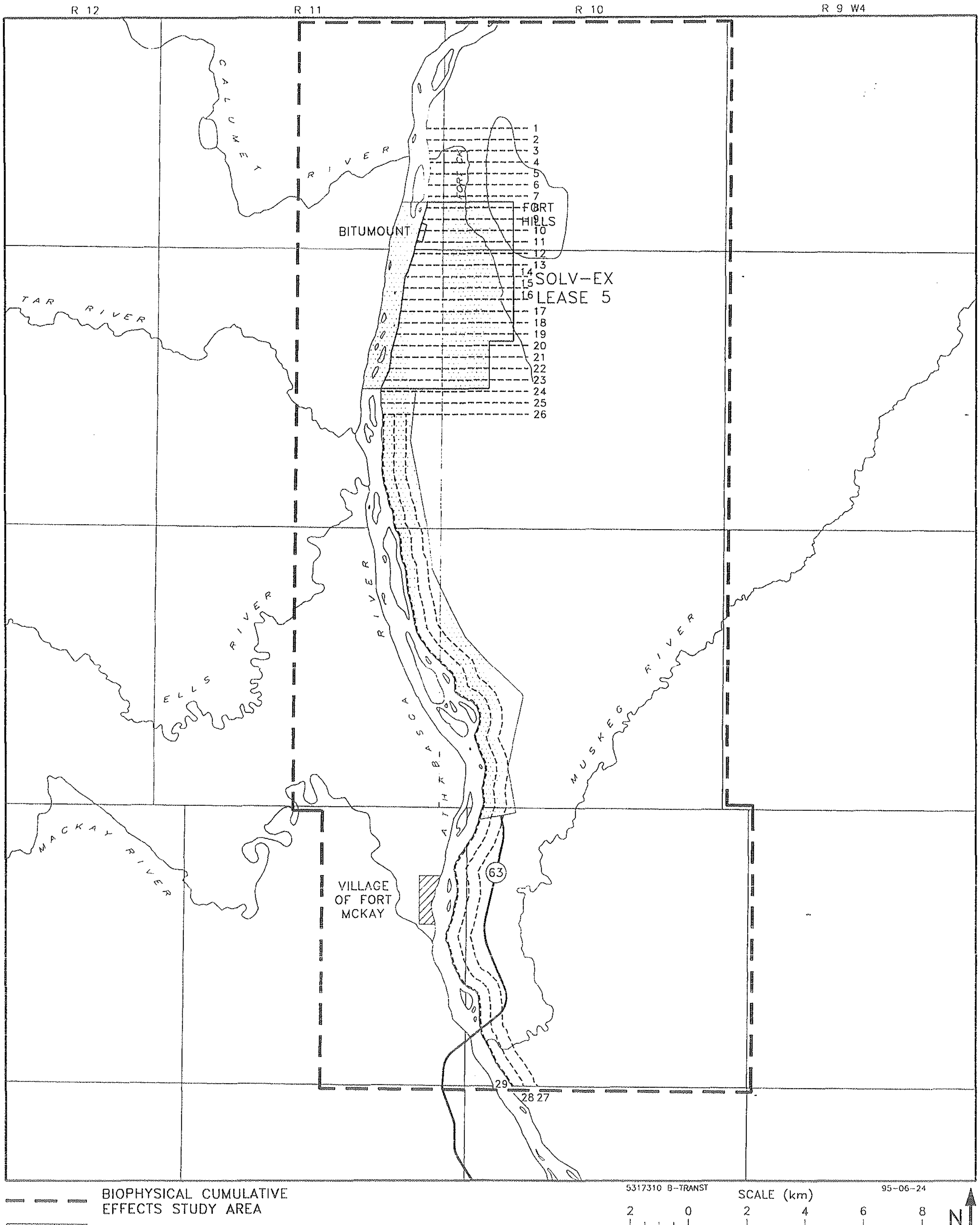

Figure VII.1 Transects for Ungulate Aerial Survey.

Table VII.1 Flight and survey conditions for the Ungulate Aerial Survey.

Date	March 29, 1995
Aircraft	206 Jet Ranger
Registration	CJ-GJX
Navigator	Rick Rowell
Observers	Judy Smith, William Grandjambe
Cloud Cover	Clear
Temperature	5°C
Wind	Nil
Light Conditions	Bright
Snow Cover	80 - 100% although some south-facing slopes were clear of snow
Total flying time	1.7 hours
Snowfall of approximately 5 cm occurred	March 24, 1995

Table VII.2 Results of Ungulate Aerial Survey.

Species	**Total Number**	**Area**	**Density**
Moose	1	76.4 km^2	0.013 moose/km^2

Table VII.3 Results of Wildlife Track Survey on March 29, 1995.

Habitat Type	Track Intercepts/km								
	Hare	Red Squirrel	Grouse	Weasel	Fisher	Marten	Fox	Coyote	Lynx
Aspen (I=2918 m)	13.4	7.2	5.8	0.7	0.7	0	1.4	0.7	0
Aspen-White Spruce (I=2186 m)	27.4	0.5	5.0	1.4	1.8	0	1.4	0.5	0
White Spruce (I=1666 m)	19.2	23.4	1.8	1.2	1.8	0	0	0.6	0
Black Spruce (I=5323 m)	11.1	4.5	1.3	2.6	1.5	0.2	0.8	0.8	0.6
Jack Pine (I=983 m)	2.0	5.1	2.0	2.0	3.0	0	1.0	1.0	0
TOTAL	73.1	40.7	15.9	7.9	8.8	0.2	4.6	3.6	0.6

There were no ungulate tracks seen in any of the transects, although two sets of deer tracks were noted as incidental along the main road.

APPENDIX VIII

VIII.1 Screening Models

The screening assessment is relatively quick and requires a minimum of data to be run. A point source screening approach was used to determine maximum SO_2, NO_x and particulate concentrations. The screening approach uses estimation techniques that are designed to produce conservative estimates of air quality changes. The models are conservative in that the assumptions are likely to result in overpredictions rather than underpredictions. The screening approach is frequently used to predict the maximum hourly average concentration that could occur under a wide range of meteorological conditions. If a screening approach indicates concentrations in excess of the ambient objectives, then a second level of more sophisticated modelling can be applied. In this assessment, the models SCREEN2 and ISCST2 developed by the U.S. EPA were used as screening models. Alberta Environmental Protection's latest *Air Quality Model Guidelines* (AEP, 1994) require their use in screening assessments and specifies the corresponding mixing heights to be input to the meteorology for ISCST2.

- **SCREEN2** was used to estimate the maximum SO_2 concentrations for rural flat and rural elevated terrain out to 25 km (or to stack top height in elevated runs) from the proposed plant site. The internal screening meteorological matrix considers 54 combinations of wind speed and stability class applied for all wind directions. The model will consider simple terrain up to the height of the stack, beyond which it is assumed level. All sources must be co-located. Receptors can be selected by the user or an internal distance array may be employed.

- **Industrial Source Complex, Short Term**, version 2 (ISCST2) will accept multiple sources and will also consider simple elevated terrain. It can use the same screening meteorological matrix as SCREEN2. Receptors can be in polar or Cartesian coordinates, the former being most useful for a single source. The Cartesian grid (regularly- or irregularly- spaced) is better for representing multiple sources. In both instances, the maximum number of receptors is limited and should be selected to ensure the maximum falls within the chosen grid.

Both SCREEN2 and ISCST2 were applied to the Solv-Ex facility emissions of SO_2 for proposed licenced and average load conditions. Both models were set up to produce predictions out to a distance of at least 20 km from the source in all directions with flat and elevated terrain. For NO_x and particulates, only ISCST2 was used due to the complex number of sources since SCREEN2 can only address single sources. In accordance with the recent *Air Quality Model Guidelines* (December 21, 1994) from Alberta Environmental Protection, the predictions from these two models were multiplied by a factor of 0.55 to produce the correct hourly, daily and annual average concentrations (both were run in "rural" mode). The input parameters for ISCST2 are summarized in Table VIII.1.

Table VIII.1 General ISCST2 model input parameters.

Model Calculation Options		
Stack tip downwash is used		
Building downwash is used		
Receptor Grid		
X, Y, Z locations		961 points in a 40 x 40 km area plus 3721 points in a 2 km x 2 km area
Terrain Data		
Source		Digitally and manually extracted from an area covering 180 x 200 km
Stack Parameters		
X, Y, Z location		0,0 for SO_2 source, various for NO_x and particulate sources
Emission rate	(g/s)	Various, see Tables 4.1.1.3, 4, 8 and 9
Stack height	(m)	Various, as above
Stack temperature	(°C)	Various, as above
Exit diameter	(m)	Various, as above
Fixed Meteorological Data		
Anemometer height		Screening: 10 m; SandAlta: 11 m
Wind profile exponents		Default
Vertical temperature gradient		Default
Hourly Meteorological Data		
Wind direction, wind speed, mixing height, ambient temperature		Various[(a)]
PG stability class		

(a) From time series meteorological data from SandAlta (April 1984 to March 1986).

VIII.2 Refined Models

Refined assessments require a time series of actual meteorological data from the nearest weather station collecting hourly climate information. The refined models used for determining air quality changes associated with the proposed Solv-Ex facility were chosen for their ability to incorporate effects of terrain and applicability to the region: ISCST2 and RTDM 3.2. Considerable experience has been acquired with the models ISCST2 in the area. As well, an alternative model, ISCON5 was employed since it was "tuned" to the oil sands area and has been applied to Syncrude and Suncor facilities. AEP suggests these models for refined assessments in conjunction with complex terrain. For assessment of SO_2 deposition, the AE model ADEPT2 was used.

- **ISCON5**. The U.S. EPA model ISCST2 was modified as a result of a study undertaken for Suncor (Concord Environmental, 1992) in consultation with Alberta Environment. It has the ability to address multiple sources and receptors for different averaging times. The model is based on a PG stability class approach. It was given the name ISCON5 to distinguish it from the original version

  The modified model uses the plume spread and terrain flow assumptions that are currently used in the Alberta Environment dispersion models. It represents an attempt to tune the emissions from oil sands area sources to correspond to observations made locally. The object of the tuning exercise was to ensure that predicted exceedences occur during the day, to reduce the number of predicted exceedences during the night, and to reduce the peak predicted concentration. Overall, the modified model produces predictions that more closely coincide with the corresponding observations.

  Limited testing showed that the model appeared to be able to predict the ensemble average within a factor of two for nearly all cases. As well, the individual peak predictions were within a factor of three to four of peak observed values. The model generally over-predicted the frequency with which exceedences occurred. However, in practice, the modifications did result in generation of predictions that were more comparable to observations than otherwise available. Another comparison of model predictions to observations for this model is presented in the Syncrude Air Quality Assessment (Concord: Vol. IV, 1992). The frequency distribution of predictions proved similar to observations, with the main difference being the absence of predictions of the infrequent extreme values. The model input parameters are summarized in Table VIII.2.

- **RTDM 3.2**. RTDM was developed by Environmental Research and Technology, Inc. (1987) and can be used to estimate ambient air quality from multiple co-located sources in rural areas. It has been adopted as an interim complex terrain model by the U.S. EPA. Although the model can be used for both flat or elevated terrain, it is especially suited for elevated terrain situations, such as exists above the stack height in the Fort Hills, Calumet uplands and further west in the Birch Mountains.

Table VIII.2 General ISCON5 model input parameters.

Model Calculation Options		
Stack tip downwash is used		
Building downwash is used		
Gradual plume rise is assumed		
Receptor Grid		
X, Y, Z locations	(m)	2401 points in a 80 x 80 km area
Terrain Data		
Source		Digitally and manually extracted from an area covering 180 x 200 km
Stack Parameters		
X, Y, Z location		0,0
SO_2 emission rate	(g/s)	See Tables 4.1.1.3, 4
Stack height	(m)	
Stack temperature	(°C)	
Exit diameter	(m)	
Fixed Meteorological Data		
Anemometer height		SandAlta: 11 m
Wind profile exponents		AE defaults for Z_o = 100 cm
Vertical temperature gradient		Default values
Hourly Meteorological Data		
Wind direction		Various[a]
Wind speed		
Mixing height		
Ambient temperature		
PG stability class		

[a] From time series meteorological data from SandAlta (April 1984 to March 1986).

It is based on a Gaussian point source dispersion model that incorporates the typical assumptions of a model of this type (e.g. wind speed and direction are uniform in space and constant throughout each simulation period; steady-state conditions are assumed with respect to emissions and meteorological parameters; etc.). It is also based on a PG stability class approach. The model can accommodate up to 35 co-located sources and 400 receptors can be considered in any single model simulation. The model can be run on an event basis (a single simulation) or in a sequential time series mode. The input parameters are summarized in Table VIII.3.

- **ADEPT2**. ADEPT2 (Alberta **Dep**osition model with **T**errain-Version **2**) is a climatological dispersion model that can be used to estimate seasonal and annual average concentrations and deposition of sulphur compounds. The following describes the ADEPT2 model features:

  - Dry deposition is estimated using the deposition velocity concept.
  - Wet deposition is estimated using a reversible scavenging concept.
  - Airflow trajectory changes due to complex terrain are based on stability-dependent correction factors.
  - Seasonal and annual joint frequency distributions of wind direction, wind speed, and atmospheric stability are required.
  - Multiple conventional and sour gas flare stacks can be evaluated.

  The chemistry in the model is limited to SO_2 sources and does not account for NO_x emissions.

  Vegetation canopies addressed by the model are as follows:

  - Urban
  - Agriculture
  - Range
  - Agriculture-range mixture
  - Deciduous forest
  - Coniferous forest
  - Forested swamp
  - Swamp
  - Water

  A uniform deposition canopy is assumed for each model run. The ADEPT2 code also has an output option that provides concentration values in a format that can be readily adapted for input into objective analysis and plotting packages.

Table VIII.3 RTDM control parameters.

Parameter	Variable	Description	RTDM Default	Solv-Ex Plant
1	HSCALE	Horizontal scale factor. Default converts km to m.	1000	1000
2	VSCALE	Vertical scale factor. Default converts ft. to m	0.3048	1.0
3	USCALE	Wind speed scale factor. Default converts mph to m/s.	0.4471	1.0
4	ZWIND1 ZWIND2 IDULUT ZA	1st anemometer height (m) 2nd anemometer height (m) Wind #1 at stack top = 0 Wind #1 at plume height = 1 Wind #2 at plume height = 2 Difference in stack base and anemometer base (m).	10 10 0 0	11 - 1 1
5	EXPON	Default stability dependent wind speed power law profile exponents.	0.09, 0.11 0.12, 0.14 0.20, 0.30	0.09, 0.11 0.12, 0.14 0.20, 0.30
6	ICOEF	Switch for selecting stability dependent plume spreads: user specified = 1, PG = 2, Briggs = 3. To be used if no on-site turbulence data are available.	3	3
7	XY1, XY2 AY, BY, CY	User supplied power law coefficients for crosswind plume spreads.	best fit to Briggs	N/A
8	XZ1, XZ2, AZ, BZ, CZ	User supplied power law coefficients for vertical plume spreads.	best fit to Briggs	N/A
9	IPPP, PPVPTG	Switch for selecting partial penetration do not use = 0 use = 1 δq/δZ for layer above inversion base (K/m)	0 0.006	0 N/A
10	IBUOY, ALPHA	Switch for buoyancy enhanced dispersion do not use = 0 use = 1 Specify a (s = plume rise/a).	1 3.162	1 3.162
11	IDMX	Switch for unlimited mixing height in stable conditions do not use = 0 use = 1	1	1

Table VIII.3 Continued.

Parameter	Variable	Description	RTDM Default	Solv-Ex Plant
12	ITRANS	Switch for gradual plume rise final plume rise = 0 gradual plume rise = 1	1	1
13	TERCOR	Stability dependent plume path correction factor	0.5, 0.5, 0.5 0.5, 0.5, 0.5	0.5, 0.5, 0.5 0.5, 0.5, 0.5
14	RVPTG	Default $\delta q/\delta Z$ for PG class E and F (K/m)	0.02, 0.035	0.02, 0.035
15	ITIPD	Switch for stack-tip downwash do not use stack-tip downwash = 0 use stack-tip downwash = 1	0	1
16	IY	Switch to use s_θ to estimate crosswind spread do not use = 0 use = 1	0	0
17	IZ	Switch to use σ_ϕ to estimate vertical spread do not use = 0 use = 1	0	0
18	IRVPTG	Switch to use $\delta q/\delta Z$ for plume rise do not use = 0 use = 1	0	0
19	IHVPTG	Switch to use $\delta q/\delta Z$ for Hcrit do not use = 0 use = 1	0	0
20	ISHEAR, SHCOEFF	Switch to use horizontal wind shear do not use = 0 use = 1	0, 0.17	0, 0.17
21	IEPS	Switch to use hourly wind speed profile exponents do not use = 0 use = 1	0	0
22	IREFL	Switch to use partial surface reflection do not use = 0 use = 1	1	1

Table VIII.3 Concluded.

Parameter	Variable	Description	RTDM Default	Solv-Ex Plant
23	IHORIZ, SECTOR	Switch for using crosswind distribution function off centreline for all stability = 0 sector averaging for all stabilities = 1 sector averaging for stable = 2 off centreline for non-stable = 3	2	2
		Stability dependent sector width	22.5, 22.5, 22.5 22.5, 22.5, 22.5	22.5, 22.5, 22.5 22.5, 22.5, 22.5
24	IEMIS	Switch for use of hourly stack emissions constant emission value = 0 hourly value = 1	0	0
25		Switch for case study output do not use = 0 use = 1	0	0

Tables VIII.4 and VIII.5 summarize the input parameters required by the ADEPT2 model for the fuel oil and natural gas cases, respectively, and the values adopted for use in the oil sands region. A STAR data set was derived for the SandAlta meteorological data set. The ADEPT2 model assumes that the wind speeds are observed from an anemometer placed at 10 m and scales the winds from this level to the stack height. This portion of the code was adapted to allow input of the anemometer heights for the data set in use.

ADEPT2 appears to be the only available model that can be used to estimate wet and dry deposition on local to regional scales. There are other dispersion models the can be used on regional to long-range scales, but none of these appear to be designed to provide predictions on a local scale.

ISCON5 was used to predict hourly average, daily average, annual average and growing season average SO_2 concentrations from the four continuous emission sources (Solv-Ex, Syncrude main, Suncor incinerator, Suncor powerhouse). The average 1994 SO_2 emissions were used for the Suncor sources, the 1994 average for Syncrude and the average emissions for Solv-Ex. The future case represents a proposed SO_2 emission reduction by Suncor (Suncor 1995). The two meteorological data sets of OSLO and SandAlta were used. A summary of the overlapping emission parameters is provided in Table 4.1.1 in Section 4.1.1.

ADEPT2 was used with average and future emissions for all sources and a case with Solv-Ex alone to determine its contribution to the total sulphur deposition. Contours of SO_4^{-2} deposition (kg/ha/a) were created for these cases.

VIII.3 Terrain

Terrain can be classified as *flat*, *simple* or *complex* according to the definitions of AEP in their latest guideline (AEP, 1994). If the source is surrounded by terrain at roughly the same elevation (or gently rolling) it is considered flat. Terrain above the source up to the height of the emitting stack is considered simple. Above this, the terrain is defined as complex. In the area surrounding the proposed Solv-Ex facility, the terrain can be classified as complex since the land surface rises slightly above the tallest stack on site (Fort Hills and Birch Mountains). Terrain information was manually extracted from 1:50 000 scale topographic maps of the region and supplemented with digital 1:20 000 scale data approximately 50 km in all directions of the proposed site. The terrain information input to the models is summarized in Tables VIII.6 and VIII.7 for SCREEN2 and RTDM, respectively. ISCST2 terrain is a series of 1941 Cartesian coordinates taken from the digital and manually-extracted terrain information.

Table VIII.4 General ADEPT2 model input parameters for natural gas combustion.

Timing:	Historical								Future		
	Solv-Ex Main	Power Boiler	Double Salt Dryer	Fines Dryer	Alumine Dryer	Suncor Powerhouse	Suncor Incinerator	Syncrude Main	Suncor Powerhouse	Suncor Incinerator	Syncrude Main
Plant Parameters (Block 3)											
Total stack flow rate (m^3/s)	15.52	23.46	30.11	6.07	2.54	326.7	19.0	671.4	442.1	17.5	671.4
SO_2 flow rate (t/d)	6.0	0.64	0.48	0.17	0.60	210.5	30.5	226	28	22	260
Stack exit temperature (°C)	250	230	200	230	99	256	490	235	63	539	235
Stact exit diameter (m)	1.35	1.6	1.5	0.9	0.6	5.8	1.8	7.9	7.01	1.8	7.9
Stack height (m)	60	33	53	53	33	106.7	106.7	183	137	106.7	183

Parameter	Units	Value
Terrain Data (Block 5)		
Canopy height	(m)	10 m
Land use		Coniferous forest
Grid		100 x 100 km
Window		Set to Biophysical study area
Meteorological Data (Block 6)		
Precipitation rate	(mm/h)[a]	0.094/0.282/0.901/0.319
Mixing height	(m)	390/1000/1000/800
Plume rise constant[b]		1.6/2.4
Potential temperature gradient	(C°/m)[c]	0.02/0.04
Ambient temperature	(°C)	-18.1/0.9/15.1/1.4
Conversion rate	(%/h)	2.0
Wet Deposition (Block 7)		
Background pH[d]		4.7
Time fraction of precipitation[a]		0.37/0.144/0.109/0.188
STAR Data (Block 8)		Joint frequency distribution of wind direction, wind speed, and stability class based on SandAlta meteorological data set

(a) Seasonal values for winter/spring/summer/fall.
(b) Values for unstable/neutral/stable conditions.
(c) Values for stability classes E/F.
(d) Alberta Environment, 1989 to 1993 data.

Table VIII.5 General ADEPT2 model input parameters for natural gas combustion.

Timing:		Historical				Future		
		Solv-Ex Main	Suncor Powerhouse	Suncor Incinerator	Syncrude Main	Suncor Powerhouse	Suncor Incinerator	Syncrude Main
Plant Parameters (Block 3)								
Total stack flow rate	(m^3/s)	15.52	326.7	19.0	671.4	442.1	17.5	671.4
SO_2 flow rate	(t/d)	6	210.5	30.5	226	28	22	260
Stack exit temperature	(°C)	250	256	490	235	63	539	235
Stack height	(m)	60	106.7	106.7	183	137	106.7	183

Terrain Data (Block 5)		
Canopy height	(m)	10 m
Land use		Coniferous forest
Grid		100 x 100 km
Window		Set to Biophysical study area
Meteorological Data (Block 6)		
Precipitation rate	(mm/h)[(a)]	0.094/0.282/0.901/0.319
Mixing height	(m)	390/1000/1000/800
Plume rise constant[(b)]		1.6/2.4
Potential temperature gradient	(C°/m)[(c)]	0.02/0.04
Ambient temperature	(°C)	-18.1/0.9/15.1/1.4
Conversion rate	(%/h)	2.0
Wet Deposition (Block 7)		
Background pH[(d)]		4.7
Time fraction of precipitation[(a)]		0.37/0.144/0.109/0.188
STAR Data (Block 8)		Joint frequency distribution of wind direction, wind speed, and stability class based on SandAlta meteorological data set

(a) Seasonal values for winter/spring/summer/fall.
(b) Values for unstable/neutral/stable conditions.
(c) Values for stability classes E/F.
(d) Alberta Environment, 1989 to 1993 data.

Table VIII.6 Composite worst case terrain heights used in SCREEN2.

Downwind Distance[a] (km)	Terrain Elevation[b] (m)	Elevation Difference (m)	Direction[c]
0.0	285	0	—
0.1	286	1	E
0.2	286	1	E
0.3	286	1	E
0.4	287	2	E
0.5	287	2	E
0.6	288	3	E
0.7	288	3	E
0.8	289	4	E
0.9	289	4	E
1	290	5	E
1.25	291	6	E
1.5	292	7	E
1.75	293	8	E
2	295	10	E
2.25	296	11	E
2.5	297	12	E
2.75	298	13	E
3	300	15	E
3.25	317	32	E
3.5	325	40	ENE
3.75	338	53	NE
4	363	78	NE
4.25	363	78	NE
4.5	363	78	NE
4.75	363	78	NE
5	363	78	NE
6	374	89	NE
7	374	89	NE
8	374	89	NE
9	374	89	NE
10	374	89	NE
12.5	374	89	NE
15	376	91	WNW
17.5	413	128	WNW
20	486	201	WNW

(a) Location refers to the distance from the main SO_2 stack. Beyond 4.3 km, the terrain elevations are assumed to be constant at 345 m in the model.

(b) Terrain elevations are expressed in metres above sea level; the base of the incinerator stack is 285 m, and the top of the stack is 345 m.

(c) Direction from plant to terrain receptor.

Table VIII.7 Terrain data used by RTDM[a]: Distances from the Solv-Ex main stack to specified elevation contours.

Wind Direction	Contour Elevation[b]																		
(m) / (ft)	300 / 984	311 / 1019	321 / 1053	332 / 1088	342 / 1122	353 / 1157	363 / 1191	374 / 1226	384 / 1261	395 / 1295	405 / 1330	416 / 1364	426 / 1399	437 / 1433	447 / 1468	458 / 1502	468 / 1537	479 / 1571	489 / 1606
10	13.23	19.72																	
20	10.88	15.48																	
30	10.45	13.94	21.60	24.30															
40	8.59	15.83	18.75	23.30	24.60	26.27	27.94												
50	8.18	13.72	15.73	18.28	20.27	22.18	24.04												
60	8.18	12.57	14.22	15.44	17.29	18.44	20.04												
70	9.30	11.11	12.61	13.81	15.18	16.76	17.66	18.53	19.52	20.52									
80	8.99	10.59	11.97	12.86	13.74	15.09	16.22	16.89	17.54	18.23	19.02	19.82							
90	8.51	10.03	11.19	12.23	12.97	13.71	14.67	15.73	16.46	17.07	17.70	18.34	18.95	19.57					
100	7.69	9.43	10.72	11.81	12.69	13.43	14.09	14.96	15.92	16.70	17.33	17.78	18.23	18.68	19.15	19.63	20.10	20.57	
110	7.41	9.44	10.78	11.92	12.81	13.47	14.10	14.77	15.66	16.42	17.18	17.64	18.07	18.47	18.85	19.21	19.55	19.83	20.08
120	7.07	9.64	10.95	12.00	12.98	13.70	14.35	14.99	15.66	16.42	17.18	17.80	18.18	18.54	18.89	19.26	19.62	19.93	20.17
130	6.86	7.32	11.10	12.22	13.17	14.17	15.03	15.67	16.27	16.84	17.48	18.11	18.66	19.12	19.56	19.98	20.37	20.73	21.08
140	6.30	6.41	6.59	7.19	7.96	15.07	15.76	16.38	16.95	17.43	17.91	18.39	18.88	19.38	19.87	20.26	20.63	20.99	21.33
150	6.27	6.50	6.59	7.34	8.31	15.87	16.61	17.38	18.03	18.66	19.27	20.26	21.19	21.64	22.03	22.39	22.72	23.03	23.32
160	6.32	6.38	6.49	6.71	16.55	18.72													
170	7.07	7.36	7.46	7.62															
180	(d)																		
190	(d)																		
200	4.60	4.74	4.96	5.20															
210	3.76	3.89	3.93	3.95	4.10														
220	3.50	3.62	3.66	3.71	3.78	3.90	5.13												
230	3.26	3.35	3.58	3.75	3.80	3.88													
240	3.24	3.31	3.42	3.63	4.07														
250	3.12	3.23	3.32	3.78	4.20														
260	3.10	3.19	3.29	4.04	4.83	6.35													
270	3.22	3.33	3.47	4.20	5.01	5.74													
280	3.42	3.49	3.57	5.26	6.71														
290	3.76	3.87	3.99	5.44															
300	4.44	4.57	4.75	6.33															
310	5.62	5.79	6.27	25.18															
320	7.05	19.67	22.84	25.65															
330	8.70	20.51	22.78																
340	8.93	21.34																	
350	(d)																		
360	15.23																		

(a) Origin (0,0) is the sulphur plant incinerator stack.
(b) Wind direction is measured clockwise from south.
(c) Plant elevation is 284.7 m (934.1 ft).
(d) Flat terrain was given at least 15 receptor points along the ray.

APPENDIX IX Fort McKay Human Resource Inventory

FORT MCKAY

HUMAN RESOURCE

INVENTORY

APRIL, 1995

The Fort McKay Human Resource Inventory was completed April, 1995, on behalf of the Solv-ex Corporation for inclusion in the Socio-Economic Impact Assessment portion of their application to the Alberta Energy and Utilities Board. The statistical data contained in this report was obtained directly from Fort McKay residents via personal and telephone interviews. These interviews were conducted by The Tri-Am Group Inc. and an employee of the Fort McKay First Nation. This Human Resource Inventory provides detailed, quantitative information relating to education, employment experience, the unemployed and career desires of the people of Fort McKay.

2.1 FORT MCKAY CURRENT LABOUR FORCE

OCCUPATION	FULL-TIME EMPLOYEES MALE	FULL-TIME EMPLOYEES FEMALE	PART-TIME EMPLOYEES & SEASONAL EMPLOYEES MALE	PART-TIME EMPLOYEES & SEASONAL EMPLOYEES FEMALE	UNEMPLOYED (BOTH UIC AND NON-UIC) MALE	UNEMPLOYED (BOTH UIC AND NON-UIC) FEMALE	DESIRE MALE	DESIRE FEMALE
ADMINISTRATION & MANAGEMENT	N - 3 M - 0 O - 0	N - 2 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 1 M - 0 O - 0	N - 0 M - 0 O - 0	N - 5 M - 1 O - 0	N - 2 M - 0 O - 2
TEACHING	N - 0 M - 0 O - 1	N - 1 M - 0 O - 2	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 1	N - 2 M - 0 O - 2
MEDICAL & HEALTH	N - 0 M - 0 O - 0	N - 2 M - 1 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 6 M - 1 O - 0
RELIGIOUS	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0
CLERICAL	N - 0 M - 0 O - 0	N - 4 M - 0 O - 3	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 6 M - 0 O - 3	N - 0 M - 0 O - 0	N - 7 M - 1 O - 6
RETAIL SALES	N - 0 M - 0 O - 0	N - 2 M - 1 O - 1	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 4 M - 1 O - 0	N - 0 M - 0 O - 0	N - 4 M - 1 O - 1
SERVICES JANITORIAL & MISC.	N - 0 M - 0 O - 0	N - 3 M - 0 O - 0	N - 1 M - 0 O - 0	N - 1 M - 1 O - 1	N - 0 M - 0 O - 0	N - 8 M - 5 O - 2	N - 0 M - 0 O - 0	N - 9 M - 4 O - 1
HUNT/TRAP/ FISH	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 3 M - 0 O - 0	N - 2 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 3 M - 0 O - 0	N - 2 M - 0 O - 0
FORESTRY	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0
CONSTRUCTION/ LABOUR	N - 7 M - 3 O - 4	N - 1 M - 1 O - 0	N - 3 M - 0 O - 3	N - 1 M - 0 O - 0	N - 8 M - 5 O - 5	N - 8 M - 0 O - 1	N - 5 M - 5 O - 6	N - 7 M - 0 O - 1
EQUIPMENT OPERATORS	N - 2 M - 1 O - 1	N - 0 M - 0 O - 0	N - 1 M - 0 O - 0	N - 0 M - 0 O - 0	N - 4 M - 1 O - 0	N - 0 M - 0 O - 0	N - 4 M - 3 O - 1	N - 0 M - 0 O - 0

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TRUCKING & TRANSPORT.	N - 4 M - 0 O - 1	N - 6 M - 2 O - 0	N - 2 M - 0 O - 0	N - 2 M - 1 O - 0	N - 0 M - 0 O - 0	N - 1 M - 0 O - 0	N - 4 M - 0 O - 2	N - 7 M - 1 O - 0
OIL SANDS OPERATION	N - 7 M - 0 O - 3	N - 6 M - 0 O - 0	N - 1 M - 1 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N -18 M - 2 O - 8	N -11 M - 4 O - 0
O/S PLUMBER	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0
O/S ELECTRICIAN	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0
O/S WELDER	N - 1 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 3 M - 1 O - 0	N - 0 M - 0 O - 0
O/S MILLWRIGHT	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0
O/S CARPENTER	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 1 M - 0 O - 0	N - 0 M - 0 O - 0
O/S MECHANIC	N - 2 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 2 M - 0 O - 0	N - 0 M - 0 O - 0
O/S EQUIPMENT OPERATOR	N - 6 M - 1 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 1 O - 0	N - 0 M - 0 O - 0	N - 7 M - 1 O - 0	N - 5 M - 0 O - 1
ENVIRONMENTAL	N - 0 M - 0 O - 1	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 1	N - 1 M - 0 O - 0
LAW ENFORCEMENT	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 0 O - 0	N - 0 M - 1 O - 0	N - 0 M - 0 O - 0
TOTAL:	N - 32 M - 5 O - 11	N - 27 M - 5 O - 6	N - 11 M - 1 O - 3	N - 6 M - 2 O - 1	N - 13 M - 7 O - 5	N - 27 M - 6 O - 6		

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2.1 FORT MCKAY CURRENT LABOUR FORCE - ADDITIONAL INFORMATION

- Key for the breakdown above is as follows:

  N - Native (Treaty)
  M - Metis
  O - Other Non-Aboriginal

- TOTAL SURVEYED - #184

- #8 - Elders and #2 - Disabled Community Members were also Surveyed but are not looking for work.

- The Fort McKay Census which was taken by I. D. #18 (Municipality) on March 1, 1995, shows a Total Population of #332 people. Male/Female residents under the age of 18 years is #130 which brings the Employable Population to #202 people.

- Below is a breakdown of the 174 Employable People Surveyed into age categories:

BREAKDOWN BY AGE

	18-30	31-45	46-60+
Native	50	43	23
Metis	14	9	3
Other	8	16	8
TOTAL:	72	68	34

- Total number of unemployed (Surveyed Labour Force) is 64 or 37%. Out of 64 unemployed it was determined (to the best of our ability) that 5 are receiving UIC and there is an estimated average of 15 adults per month on Social Assistance.

- Please note that 75% of the Part-Time and/or Seasonally Employed people would like to work Full-Time.

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2.2 FORT MCKAY - CURRENT TRAINING PROGRAMS

- Due to the lack of University or Technical Programs taken by Employable people, there is very little to report in this category. The Breakdown of people who have completed or are in progress of completing training programs are as follows:

		Male	Female
Grade 12 Diploma or Upgrading to G.E.D.	-	15	17
University Program	-	1	-
Management Programs (Through Employers)	-	1	-
Apprenticeship Program (Trades)	-	2	-
Forestry	-	1	-
Computer Programs	-	-	3
Heavy Equip. Operator	-	2	-

- Please note that All Employees of the Oil Sands Plants must complete an Entrance Exam, relative Safety Courses and Management Programs, which relate to their jobs. These courses are funded and taught by the Oil Sands Plants.

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2.3 FORT MCKAY - CURRENT BUSINESS SUPPLY/SERVICE CAPABILITY

FORT MCKAY DEVELOPMENTS LTD. (FORT MCKAY GROUP OF COMPANIES)

Company in business since 1986

Personnel:

Len Mason, General Manager - 20+ years experience
Lila L'Hommecourt, Financial/Administration Manager - 1 yr.

Fort McKay Developments is the administration body for all the Corporations and is owned by Fort McKay First Nation.

1) FORT MCKAY GENERAL CONTRACTING LTD.

Company in business for nine years (1986)

Services Provided:

Provide labour/janitorial crews
Treeclearing, brushclearing with equipment
Fencing
Ice bridges
Landscaping, clearing

Contracts Completed:

Dismantled Husky Plant Site (still approx. 1 month work employing 2-3 F/T temp.).
Ice Bridge (Suncor) approx. 2 mos. F/T temp. work seasonal.
Suncor labour contract (groundskeeping, maintenance), this contract has been renewed to 1997 employing 6 F/T, 4 P/T employees with possibilities to expand.
Suncor janitorial contract also renewed employing 15 F/T, 4 P/T.
A.O.S.T.R.A. completed 5 year contract, currently negotiating contract, employs 2 F/T janitorial crew, 2 back-up, and 1 - 1st yr. welding apprentice.
Syncrude North Lease - completed three month contract will be on-going, seasonal work.
Alberta Forestry - completed standtending contract Aug./94.
Completed several short term brushclearing jobs with various companies.
Alberta Municipal Affairs (I.D.18) - maintenance of landfill site in community or required basis.

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Management Personnel:

Mickey Demers, Manager with 3.5 years experience

Operations Personnel:

Gordon Klippenstein, Labour Contract Administrator
Janet Davis, Supervisor, Suncor Janitorial

Vehicles:

1 - 87 Ford Ranger
1 - 87 Dodge Van
1 - 94 Ford F250
1 - 88 Ford F350
1 - 89 Chevrolet
1 - 93 Ford
1 - 76 Chevrolet
1 - 85 Ford
1 - 93 Aerostar
1 - 89 Ford Van
1 - 95 Ford F350

Equipment:

1 - 89 428 Backhoe c/w post pounder, bucket
1 - 86 D6D Cat c/w blade, rake
Brushsaws, chainsaws w. tool kits, safety equipment, outdoor equipment (tents, tarps, camping equipment, fuel containers), treeplanting equipment, 2 tidytanks, various tools.

2) FORT MCKAY TRANSPORTATION:

Company in business since 1988.

Services Provided:

Contract bussing
Charters (including interprovincial)
Student Transportation (Ft. McKay/Ft. McMurray)
Medical transportation to Fort McMurray
Shop facilities maintaining buses, vehicles, incl. intercompany servicing of vehicles.
Mailroom distribution (Syncrude Contract)
Coveralls distribution (Suncor)

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Contracts Completed:

Completed 5 year contract with Syncrude, renewed contract for 5 years with possibility of extension.

Management Personnel:

Tony Wintonyk, Manager with 15 years experience

Operations Personnel:

Transportation Supervisor, Vacant position pending selection
Manfred Lee - Journeyman Mechanic
10 F/T - Bus Drivers, 4 P/T Bus Drivers all with Class 2
2 Shop cleaning Crew
2 P/T Labourers
5 F/T Mailroom Clerks, 2 P/T Back-up Crew

Vehicles:

1 - 87 Chev Bus
1 - 92 Ford Aerostar
10 - 88 Ford 22 Passenger Bus
1 - 90 Ford 25 Passenger Bus
1 - 47 Passenger Coach

Equipment:

Mobile Radios, Shop Equipment

3) Fort McKay General Store

Company in business since 1986.

Personnel:

Sandra Boucher, Manager

Description:

Fort McKay General Stores Ltd. provides services to the general public which includes a gas bar, laundromat facilities, groceries, and Native Handicrafts.

4) Fort McKay Environment Services Ltd.

Company in business for nine years (1986)

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Services Provided:

Treeplanting
Fencing
Environmental Monitoring
Wildlife Management

Contracts Completed:

Suncor 93/94 Monitoring
Syncrude Bison Fencing Project
Syncrude Tree Planting 1994 Season
Wildlife Management, Syncrude, several projects completed

Management Personnel:

Bonnie Evans, Manager with 13 years experience

Operations Personnel:

Brad Ramstead, Reclamation Technician, 5 years experience
Raymond Ratfat, Bison Ranchhand, 2 years experience
Tony Clements, Operator 1, 4 years experience
All of the above employees are Full-Time.

Vehicles:

1 - 93 Suzuki Sidekick
1 - 94 Suzuki Sidekick

Equipment:

1 - 92 John Deere Tractor c/w attachments
1 - 89 Artsway Disc. c/w attachments

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<u>OTHER FORT MCKAY BASED COMPANIES</u>

1) **THUNDERBIRD**
General Delivery
Fort McKay, Alberta

Clara Wilson - Owner/Operator

This company is responsible for transporting people to and from the Hospital, Clinics, and Medical Appointments (Fort McKay/Fort McMurray). The company has several light duty vehicles for this purpose.

2) **NEEGAN DEVELOPMENTS & Tuc's Trucking**
General Delivery
Fort McKay, Alberta

David Tuccuro - Owner

This company provides equipment and employees for varies types of Construction (Oil Sands related) and Heavy Equipment Operations.

3) **ENVIRONMENT ELECTRONICS ELECTRICAL SERVICES INC.**
General Delivery
Fort McKay, Alberta

Jim and Shirley Dunning - Owners
20+ years experience in the Electrical Field
Employees:

15 Full-Time Electricians (Journeyman and Apprentice)

Contract Completed:

Syncrude - Mining Maintenance Service
Suncor - Electrical Maintenance

Description:

This company provides the Oil Sands Plants with Electricians on a contract basis.

Vehicles:

6 - Light Duty 1/2 Ton Trucks and Equipment

continued...

4) Sandra Boucher
General Delivery
Fort McKay, Alberta

Sandra Boucher - Owner/Operator

This company is responsible for the transportation of people to and from Medical Services in Fort McMurray. The company has light duty vehicles for this purpose.

UNEMPLOYED - BREAKDOWN BY AGE CATEGORY

18-30		31-45		46-60	
NATIVE	- 17	NATIVE	- 13	NATIVE	- 12
METIS	- 6	METIS	- 4	METIS	- 3
NON-ABORIGINAL	- 2	NON-ABORIGINAL	- 5	NON-ABORIGINAL	- 2
TOTAL:	25		22		17

GRAND TOTAL UNEMPLOYED: 64

continued...

BREAKDOWN OF DESIRE CATEGORY FROM FORT MCKAY CURRENT LABOUR FORCE

CATEGORY	TOTAL	BREAKDOWN OF TOTAL
Administration & Management	10	5 - Currently employed in field. 1 - Unemployed in field. 4 - From Clerical & Oil Sands Operation.
Teaching	5	4 - Currently employed in field. 1 - From Retail.
Medical & Health	7	3 - Currently employed in field. 4 - Unemployed Services & Janitorial.
Religious	-	-
Clerical	14	3 - Currently employed in field. 9 - Unemployed in field. 2 - Oil Sands Operation
Retail Sales	6	2 - Currently employed in field. 4 - Unemployed in field.
Services & Janitorial	14	4 - Currently employed in field. 10 - Unemployed in field.
Hunt/Fish/Trap	5	4 - Currently do Part-Time. 1 - Heavy Equipment Operator.
Forestry	-	-
Construction/Labour	24	13 - Currently employed in field. 11 - Unemployed in field.
Equipment Operators	8	5 - Currently employed in field. 3 - Unemployed in field.
Trucking/Transport	14	10 - Currently employed in field. 1 - Unemployed in field. 3 - Unemployed Construction/Lab.
Oil Sands Operation	43	18 - Currently employed in field. 25 - Unemployed and Employed Construc./Lab. or Equip. Op.

continued...

CATEGORY	TOTAL	BREAKDOWN OF TOTAL
O/S Plumber	-	-
O/S Electrician	-	-
O/S Welder	4	1 - Currently employed in field. 3 - Employed & Unemployed Construc./Labour.
O/S Millwright	-	-
O/S Carpenter	1	1 - Employed Construc./Labour.
O/S Mechanic	2	2 - Currently employed in field.
O/S Equip. Operator	14	7 - Currently employed in field. 7 - Unemployed Clerical/ Construction/Labour/Janitor.
Environmental	2	1 - Currently employed in field. 1 - Employed Clerical.
Law Enforcement	1	1 - Unemployed Services.
TOTAL:	174	174

FORT MCKAY
EDUCATION, TRAINING AND EMPLOYMENT INFORMATION SHEET

1. LAST NAME________________________FIRST NAME:_________________________
2. DATE OF BIRTH: YR.______ MONTH__________ DAY__________
3. SEX M F
4. MARITAL STATUS: SINGLE COMMON LAW MARRIED
5. NUMBER OF DEPENDENTS:________
6. AGES OF DEPENDENTS:________ __________ __________ __________
7. DO YOUR DEPENDENTS LIVE WITH YOU?
   YES_______ NO________
8. STATUS:
   TREATY NON-TREATY METIS WHITE OTHER
9. TREATY NUMBER_____________________
10. SOCIAL INSURANCE NUMBER_______________________________________
11. RESIDENCY:
    FORT MCKAY FORT MCMURRAY OTHER___________________
12. LANGUAGE(S) SPOKEN:
    CREE_________ CHIPEWYAN_________ ENGLISH________ OTHER______
13. LANGUAGE(S) READ & WRITTEN:
    CREE_________ CHIPEWYAN_________ ENGLISH________ OTHER_______
14. HIGHEST GRADE COMPLETED (GRADES 0 - 12)_______________________
15. YEAR HIGHEST GRADE WAS COMPLETED________________________
16. EDUCATION/TRAINING COURSES/PROGRAMS TAKEN YEAR TAKEN
    (INDICATE IF EACH OF THE FOLLOWING ARE COURSES OR PROGRAMS.)

    ____ _____________
    ____ _____________
    ____ _____________
    ____ _____________

17. EDUCATION/TRAINING COURSES/PROGRAMS COMPLETED YEAR GRAD.
    (INDICATE IF EACH OF THE FOLLOWING ARE COURSES OR PROGRAMS)
    COURSE/PROGRAM CERTIFICATE/DIPLOMA/DEGREE

    ____ _____________
    ____ _____________
    ____ _____________
    ____ _____________

18. ARE YOU ON...

    SOCIAL ASSISTANCE________ UNEMPLOYMENT INSURANCE___________
19. ARE YOU WORKING?

    NO______ IF YES, NAME OF EMPLOYER____________________________
20. WHO WAS YOUR LAST EMPLOYER? (IF UNEMPLOYED)

    ____

CONTINUED...

21. DID YOU HAVE ANY OF THE FOLLOWING PROBLEMS IN YOUR LAST JOB WITH:

YOUR SUPERVISOR?
YOUR CO-WORKERS?
DRINKING?
DRUGS?
DRIVING INFRACTIONS?
LATENESS?
NOT KNOWING WHAT YOUR JOB WAS?
ABSENTEEISM?

22. WHAT KIND OF PROBLEMS DID YOU HAVE?

____
____
____
____

23. HOW LONG DID YOU WORK THERE?

____

24. ARE YOU <u>WILLING</u> TO WORK AT ANY TIME?

YES______ NO______ WILLING TO WORK (WHEN)?____________________

25. IF YES, WHAT TYPE OF WORK DO YOU WANT?

FULL TIME__________ PART TIME____________ CASUAL________
SEASONAL (WHEN?)____________________

26. IF YOU NEED TO TAKE COURSES, TRAINING OR TO TAKE A JOB ARE YOU WILLING TO TRAVEL...

TO FORT MCMURRAY____________ OUTSIDE OF THE REGION__________

27. TO TAKE COURSES, TRAINING OR TO TAKE A JOB ARE YOU WILLING TO LIVE...

IN FORT MCMURRAY________ OUTSIDE OF THE REGION______________

28. WHAT ARE YOUR HOBBIES OR INTERESTS?

____
____
____
____

29. WHAT ARE YOU GOOD AT?

____
____
____
____

30. WHAT DO OTHER PEOPLE SAY YOU DO WELL?

____
____
____
____
____

31. HAVE YOU EVER RECEIVED ANY AWARDS, TROPHIES OR SPECIAL RECOGNITION? (IF YES,LIST THEM.)

____
____
____

32. DO YOU PREFER TO WORK...(ASK QUESTION & GIVE OPTIONS ALL AT ONCE)

BY YOURSELF?	YES	NO
WITH 1 OTHER PERSON?	YES	NO
WITH A GROUP OF PEOPLE?	YES	NO
WITH THE PUBLIC?	YES	NO

33. WHAT TYPE OF WORK WOULD YOU LIKE TO DO NOW? (LIST 1st, 2nd, and 3rd Choices)

1st Choice______________________________
2nd Choice______________________________
3rd Choice______________________________

34. WHAT ARE YOUR WAGE OR SALARY EXPECTATIONS?

$______________PER__________________.

35. WHAT TYPE OF WORK WOULD YOU LIKE TO DO IN THE FUTURE? (LIST 1st, 2nd, and 3rd Choices)

1st Choice______________________________
2nd Choice______________________________
3rd Choice______________________________

36. WOULD YOU NEED ANY SUPPORT TO TAKE TRAINING, GET MORE EDUCATION OR START A JOB?

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____
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