ENVIRONMENTAL IMPACT ASSESSMENT SUMMARY

for the:

MUSKEG RIVER MINE PROJECT

prepared for:

Shell Canada Limited

prepared by:

Golder Associates

Calgary,
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PROJECT APPLIED FOR

Shell Canada Limited (Shell) is applying to the Alberta Energy and Utilities Board (EUB) and Alberta Environmental Protection (AEP) for approval to construct, operate and reclaim an oil sands mine and processing facilities on the western portion of Oil Sands Lease No. 7277080T13 (Lease 13). Lease 13 is located about 70 km north of Fort McMurray, Alberta (see Figure 1-1) and about 500 km northeast of Edmonton.

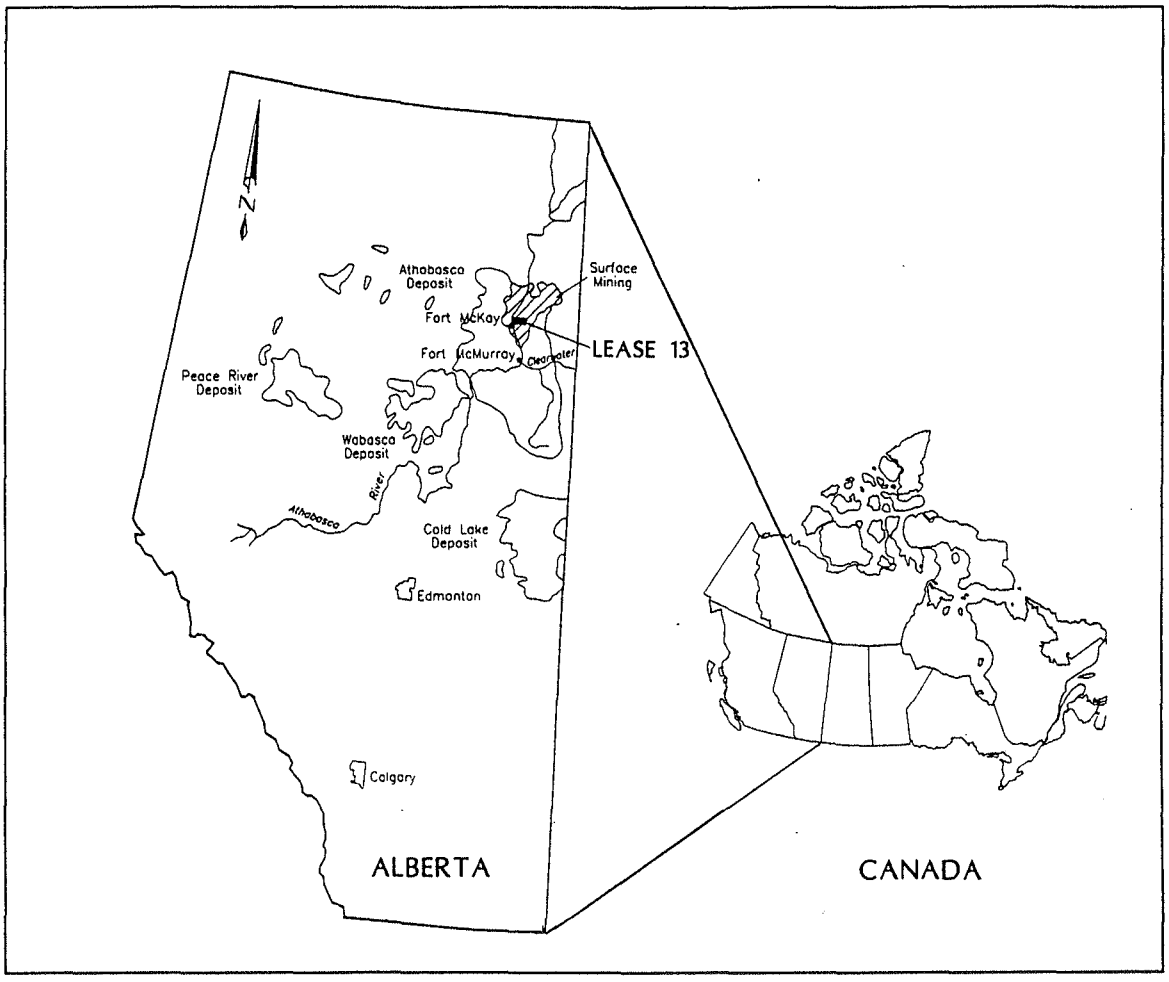

Figure 1-1: Project Location

The Muskeg River Mine Project involves mining and processing oil sands from the western portion of Lease 13 to produce a diluted bitumen (dilbit) product. The mine and extraction facilities will be located in the portion of Lease 13 which is east of the Athabasca River and west of the Muskeg River.

Lease 13 covers 20,182 ha (49,872 acres - 77 sections) in Township 95, Ranges 9 and 10, plus a small western portion of Range 8 and an eastern portion of Range 11. It has a potentially mineable bitumen resource of about 800 million m^3 (5 billion bbl). The reserves in the area of the Muskeg River Mine are assessed at about 200 million m^3 (1.3 billion bbl). The outline of the Muskeg River Mine Project area is shown in Figure 1-2.

The targeted production rate from the project area is 8.7 million m^3/a (55 million bbl/yr) of bitumen, or 23,850 m^3 (150,000 bbl) per day. At this rate, the expected mine life is over 20 years.

Shell is also requesting approval to receive third-party oil sands material at its site for processing and to ship this oil sands material from its site for processing elsewhere.

SCOPE OF PROJECT

The Muskeg River Mine Project includes:

- a truck-and-shovel mining operation
- a material crushing and conveying system
- an extraction plant with a caustic-free ore conditioning and extraction process
- a tailings management scheme
- utilities, including raw water supply, process water heating, and electrical power
- a utility service corridor

The water intake line will come from the Athabasca River and connect with the utility service corridor. The major project facilities are described in more detail in Section 1.2.

REGULATORY APPROVALS

Shell requires a number of approvals at the municipal, provincial and federal levels in order to proceed with the Muskeg River Mine Project. The required approvals vary in scope from approval of the Lease 13 development plan to approvals for radio communication licences (see Table 1-1). Most of the required approvals are new. Others are amendments or renewals of existing approvals.

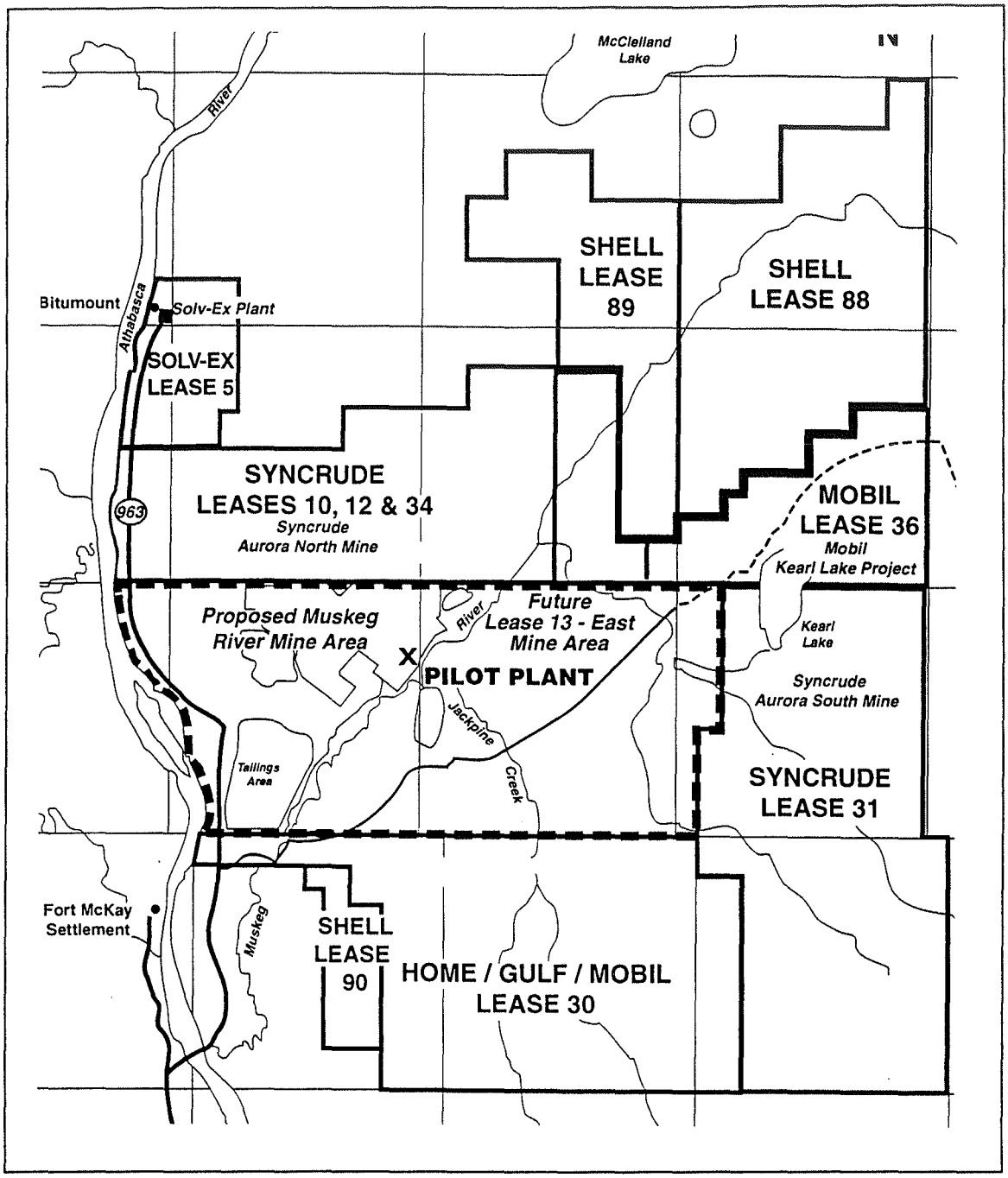

Figure 1-2: Muskeg River Mine Project Area

Bitumen product from the Muskeg River Mine will be transported to the Edmonton area via a 610-mm (24-inch) diluted bitumen pipeline. The transportation diluent will be received and returned to Lease 13 via a 323-mm (12-inch) pipeline, to be located in the same pipeline trench as the diluted bitumen line. Shell is proposing to construct a new upgrader at its Scotford refinery site in Fort Saskatchewan to produce a range of upgraded refinery

feedstocks to take advantage of the Scotford refinery's existing configuration. The bitumen product will be of an acceptable quality to also allow it to be direct-marketed as a bitumen product with low water and solids content. In early 1998, Shell plans to file applications with the EUB and AEP for the development of the upgrader. In mid-1998, an application for a pipeline from Fort McMurray to Edmonton will be filed with the EUB and AEP.

Shell is currently evaluating options for supplying electrical power to the project. Consideration is also being given to requesting an industrial system exemption under the Electric Utilities Act. Shell will file separate applications for the electrical utilities, transportation and upgrading parts of the project.

Project Approval Decision Points

The key project approval decision points are:

- receive regulatory approvals and permits for all facilities by the end of 1998
- receive Shell and BHP Board of Directors' approval by the end of 1998

Full project funding will not be authorized until all major regulatory approvals, permits and licences have been obtained.

Table 1-1: Required Regulatory Approvals

Approval	Legislation	Date Required	Agency
Oil Sands Approval	Oil Sands Conservation Act	December 1998	EUB
Water Pipeline Approval	Pipeline Act	June 1999	EUB
10 Year Approval	Alberta Environmental Protection and Enhancement Act	December 1998	AEP
Permit to Divert and Use Water	Water Resources Act	December 1998	AEP
River Crossing	Water Resources Act	December 1998	AEP
Surface Rights	Public Lands Act	December 1998	AEP
Historical Resources Clearance	Historical Resources Act	December 1998	Alberta Community Development
Radio Communications Licences	Radio Communication Act	January 2000	Industry Canada
River Crossing	Navigable Waters Act	December 1998	Coast Guard
Development Permit	Bylaw 84/2	December 1998	R.M. Wood Buffalo
OH&S New Plant	Occupational Health and Safety Act	December 1998	Alberta Labour
Industrial System Exemption	Electrical Utilities Act	December 1998	Alberta Energy

CURRENT APPROVALS

Shell currently holds several surface rights approvals on Lease 13 (see Table 1-2).

Table 1-2: Crown Disposition within Lease 13

Crown No.	Facility
MSL 11674	Test pit, temporary camp and temporary pilot
LOC 5733	Airstrip and beacon site
LOC 5732	Main access road and observation well
LOC 5772	Road to lagoon area
LOC 5728	Observation wells and access roads
LOC 5795	Lease traverse road and old airstrips
LOC 5727	Eastern pump site and access road
LOC 5729	Camp connection road
LOC 6245	Test drainage ditch
MSL 820597	Main access road
MLP 890084	Camp and associated facilities
MLL 900007	Old campsite
MLP 810038	Storage area
LOC 971997	Drainage system and access road
	Consultative notation covering Lease 13

APPROVALS RECEIVED

An application for an experimental pilot facility on Lease 13 was filed with the EUB and AEP in November 1997. Approvals were received in December 1997.

DEVELOPMENT SETTING

The Regional Municipality of Wood Buffalo represents a diverse and dynamic development setting. The Muskeg River Mine is located near the community of Fort McKay. A focused effort has been made to work closely with this community to understand their issues, concerns or interests in order to ensure understanding and mutually acceptable development.

Other regional development factors that have been incorporated into project planning include:

- existing oil sands industry operations
- approved oil sands industry developments that are under construction, such as Suncor's Steepbank Project and Syncrude's Aurora Project

- proposed oil sands industry development, such as:
  - Syncrude's Project 21 Upgrader
  - Suncor's Millennium Project
  - Mobil Oil's Kearl Oil Sands Mine Project
  - potential in situ developments
- other mineral lease holders, such as Birch Mountain Resources Ltd.
- the forest industry, including Alberta Pacific Forest Industries Inc. (Alberta-Pacific) and Northland Forest Products Ltd.
- regional transportation and utilities infrastructure
- traditional land uses

LEASE PHYSIOGRAPHY

Lease 13 is situated within the Clearwater Lowland physiographic division of the Saskatchewan Plain. Most of the lease comprises gently undulating terrain between 330 m and 284 m above sea level (masl). The eastern valley wall of the Athabasca River slopes abruptly 50 m down to river elevation (232 masl). The Muskeg River flows diagonally across the lease in a southwesterly direction. Jackpine Creek (historically known as Hartley Creek) is the largest of four tributaries that enter the Muskeg River almost at right angles from the southeast. Northwest of the Muskeg River, the lease is poorly drained, with muskeg development, but there are no significant bodies of water within the lease boundaries.

EXISTING INFRASTRUCTURE

Road Systems

Highway 63 is paved from Fort McMurray to the Peter Lougheed Bridge crossing the Athabasca River. From there, a gravel road extends to the southwest corner of Lease 13. An all-weather gravel road, built and maintained by Shell, referred to as the Lease Traverse Road, crosses Lease 13 from southwest to northeast. A 9 km gravel road connects the Shell test pit and pilot plant location with the Lease Traverse Road.

Utility Corridor

A cleared utility corridor 96 m wide extends along the southern boundary of the lease. The corridor contains an electrical power line and a 25-cm (10-inch) diameter gas line.

DEVELOPMENT PROPONENTS

Muskeg River Mine Feasibility Participants

Shell and The Broken Hill Proprietary Company Limited (BHP) are parties to a feasibility agreement for assessing and advancing the development of an oil sands project on Lease 13. This combination of a world-scale oil company and an international mining organization provides a solid base for an oil sands development.

Shell Canada Limited

Shell is one of the largest integrated petroleum companies in Canada with total annual revenues of $5.2 billion and assets of more than $5 billion. It is a major producer of crude oil, natural gas, natural gas liquids and bitumen, and is Canada's largest producer of sulphur. Shell operates three major refineries in Canada with a combined capacity of 44,500 m^3/d (280,000 bbl/d) and a national network of 2,100 Shell-brand service stations. Shell employs more than 3,600 people across Canada and has its head office in Calgary, Alberta.

The Broken Hill Proprietary Company Limited

BHP is Australia's largest public company. BHP's annual sales exceed $20 billion and its assets total more than $36 billion.

BHP was incorporated in Melbourne in 1885, and began mining silver, lead and zinc at Broken Hill, New South Wales. Today, it is a leading global resources company with more than 60,000 people employed in operations and offices in 70 countries. BHP is the world's largest non-governmental producer of copper, and the world's second largest producer of iron ore.

Public Consultation

Shell believes in the benefits of public consultation and has conducted an active communications program in the Fort McMurray area since early 1997. Shell staff have participated in a variety of community and industry forums and met regularly with representatives of regulatory agencies, aboriginal groups, local residents, community organizations, industry, special interest groups and the public, to inform them of the company's plans for developing the Muskeg River Mine and to obtain their input in developing these plans.

PROJECT INCENTIVES

Shell has held Lease 13 since 1956 and has advanced developments on several occasions. This involved making major financial commitments which lead to an improved understanding of the resource and its development potential. The ability to access the significant new reserves of the Athabasca oil sands is attractive because there is no additional cost or risk associated with finding the resource.

Project Need

Shell and BHP believe they can make a substantial contribution to sustainability and advancement of oil sands as a competitive and secure energy supply for Canada's future. The benefits expected from developing the Muskeg River Mine include:

- increasing production over the long term to replace declining conventional reserves and to provide Canada with security of energy supply
- advancing technological innovation for enhanced cost, recovery and environmental performance
- creating jobs and sustaining and diversifying local and regional economies
- encouraging new businesses and existing businesses to support the project
- contributing greatly to the corporate, personal and municipal tax base and provincial royalty base
- giving major short and long-term support to the Alberta and Canadian economies

Muskeg River Mine Project Viability

Over the past few years, several positive changes have enhanced the prospect for commercial viability of oil sands projects, including the:

- success of the existing oil sands operators in lowering unit operating costs
- evolution of mining and extraction technologies
- government's recognition of the importance of oil sands development

In addition to these general factors, which support commercial oil sands development, the Muskeg River Mine Project has two unique advantages:

- Lease 13 is a large resource with high-quality, well-defined orebodies.
- Shell's Scotford refinery is designed to exclusively process synthetic crude oil from oil sands.

Shell's proposed new upgrader next to the Scotford refinery will process the bitumen produced from the Muskeg River Mine into a range of upgraded refinery feedstocks. The Scotford advantage is derived from being able to customize the upgrader to produce feed streams that meet specific refinery capabilities. Costs of upgrading are less than those for producing synthetic crude oil for general sale in the marketplace. The feedstock will be upgraded only to the level needed for the specific refinery process, and not beyond.

RESOURCE DEFINITION

About 790 exploration wells were drilled on Lease 13 before 1996. With over 510 exploration wells in the area west of the Muskeg River, Shell has a solid understanding of the resource, to support the planning of a commercial

development. The Lease 13 eastern area, defined as the portion of Lease 13 east of the Muskeg River, is also well defined with over 280 wells.

In 1996 and 1997, additional drilling and evaluation work helped to establish a detailed geological understanding for the Muskeg River Mine Project area on the western portion of Lease 13.

A geological field program has been planned for winter 1997 and 1998. The program started with site preparation in December 1997 and will involve drilling about 130 core holes, 200 overburden wells, two pumping test wells for the aquifer and two piezometer wells. A shallow seismic program will also be conducted. The program will provide the necessary definition for the detailed design and mine operating plan.

DEVELOPMENT OF EASTERN PORTION OF LEASE 13

If the economic environment remains favourable, and subject to regulatory approval, Shell intends to further develop the eastern portion of Lease 13. Preliminary analysis has shown that this area can sustain bitumen production rates of up to 30,000 m^3/d (200,000 bbl/d) for between 30 and 40 years.

PROJECT SCHEDULE

The overall project schedule is focused on achieving production in 2002. This aggressive schedule is motivated by the need to:

- fill the projected market need and provide a secure feedstock for Shell's existing refining assets
- obtain a revenue stream as soon as possible, to offset the significant expenditures
- meet lease tenure obligations of production before 2003

The regulatory review process will proceed in 1998, in parallel with the project's more detailed front-end engineering and design (FEED) work. Approvals are required before detailed engineering starts.

Site preparation will need to start in early 1999, to be followed by facility and mine construction through to early 2002. Commissioning and start-up are planned before mid-2002.

REGIONAL COOPERATION APPROACH

Advantages of Industry Cooperation

The cooperation of nearby operators or developers is desirable from the standpoint of exploring opportunities to facilitate responsible development and

to mitigate any potentially adverse impacts. However, where common lease boundaries exist, such cooperation is essential for coordinating mine development to:

- ensure that optimal resource recovery occurs
- provide the basis for effective reclamation planning

The history of the existing Syncrude and Suncor operations demonstrates the need for and the practical application of cooperating with neighbours. Shell, BHP and all other operators share the EUB's interest in:

- minimizing resource sterilization
- optimizing environmental management
- optimizing the efficient development of the resource

Although this is of public interest, efficient and cost-effective development will also help reduce any negative impacts, which will, in turn, limit liability and maximize investor return.

Potential Areas for Cooperation

Considering the current status of proposed developments by the various companies, there are two likely hubs for cooperative activity:

- the Muskeg River West Area in 2001 and 2002 to include the Syncrude Aurora North Mine and the Muskeg River Mine

- Kearl Lake Area from 2003 onward for Mobil's Kearl Oil Sands Mine, Syncrude Aurora South Mine and Shell Lease 13 future eastern expansion

Cooperation Agreement

Shell and Syncrude have concluded, within the existing regulatory framework, a formal cooperation agreement that will promote the orderly and efficient development of Syncrude's Aurora North and Shell's Muskeg River Mine Project.

Other Mineral Rights Holders

Birch Mountain Resources Ltd. holds the industrial mineral rights in the lands that overlap and underlie Shell's oil sands lease rights. Shell, BHP and Birch Mountain staff have met to explore opportunities for cooperation, such as sharing geological and geophysical information relating to the respective crown lease holdings and coordinating field data programs.

ENVIRONMENTAL AND SOCIO-ECONOMIC MANAGEMENT

Key Environmental Issues

The key environmental issues arising from the development of the Muskeg River Mine are similar to those currently being managed by the existing operators and communities. In the past two years, two environmental impact assessments (EIAs) have been conducted in the area. One of these EIAs was conducted for Syncrude's Aurora Project, immediately adjacent to the north and southeast of Lease 13. The other was conducted for Suncor's Steepbank Mine, about 20 km due south of Lease 13.

The key environmental issues identified through consultation with stakeholders and regulators are the:

- impacts on local and regional air quality
- protection of the health of local and regional residents and project employees
- impacts on water quality
- health of the aquatic ecosystem in the Athabasca and Muskeg rivers
- impacts of surface disturbance on the terrestrial ecosystem, especially within the river valleys
- effects on traditional land use and historical resources
- cumulative effects on wildlife populations and aquatic resources

Key Socio-Economic Issues

The key socio-economic issues identified through consultation with stakeholders in the Wood Buffalo region are:

- business and employment for local residents
- training and employment opportunities for aboriginal communities
- cumulative impacts on infrastructure and community services in the municipality

Industrial Benefits

The design and construction of the project will generate an estimated 3,000 work years of employment in Alberta. About 800 full-time staff will be employed in Muskeg River Mine operation.

An estimated $1.2 billion will be spent during construction, 60% of which will accrue directly to the provincial economy. About 80% of the annual $225 million to $300 million operating expenditure will be spent in Alberta.

Impact Assessment

In May 1997, Shell filed with the Director, Environmental Assessment Division, AEP, the Proposed Terms of Reference for the Lease 13 EIA. On November 7, 1997, the Director issued the Final Terms of Reference. These terms incorporate the requirements of provincial and federal agencies and public comments. Based on these terms, Shell conducted a focused impact assessment, which includes a cumulative effects assessment.

The predicted impacts for the Muskeg River Mine Project are acceptable. The project will have no significant long-term impact on the environment, provided that the recommended mitigation measures are undertaken.

SCOPE

The major facilities required for the Muskeg River Mine Project include:

- a truck-and-shovel mining operation
- a crushing and conveying system to size and transport the material about 600 m to the processing facility
- an extraction plant that uses a warm (45°C to 50°C) water-based, caustic-free ore conditioning and extraction process and a conventional centrifuge froth treatment process, coupled with a paraffinic solvent-based product clean-up unit to meet the low solids and water bitumen specification
- a tailings settling pond for initial tailings storage and facilities for consolidated tailings (CT) production and in-pit storage after four years
- utilities and offsites to support production operations

A simplified process schematic is shown in Figure 1-3.

SITE PREPARATION

In early 1999, subject to regulatory approval, land will be cleared and prepared for facility construction overburden removal and mining.

All merchantable (coniferous and deciduous) timber will be salvaged. Wet areas will be drained, and muskeg and topsoil removed from the initial mine area. Muskeg and topsoil will be stored for reclamation purposes.

Facilities, including a truck dump, in-pit crusher, construction utilities, a temporary office and maintenance shops will be constructed by the end of 2001.

MINING

Pre-stripping of the overburden for the crusher location will begin in late 1999, using trucks and shovels. The overburden will be hauled to external disposal areas or used to construct external tailings dykes. Pre-stripping for the initial

mine pit will take place in 2001. Oil sand suitable for plant feed will be removed and stockpiled.

In spring 2002, mining of the oil sands will begin, to support commissioning of the extraction facilities. Standard truck-and-shovel methods, using large-scale equipment, will be used to mine the oil sands.

Oil sands feed to the extraction plant will be blended from a number of mining locations. This will minimize the need for blending stockpiles ahead of the extraction process. The mined oil sands will be hauled to a crushing facility located on the mine boundary adjacent to the ore extraction plant. At the crushing facility, crushers will size the oil sands to less than 400 mm (16 inches). The crushed oil sands will then be conveyed about 600 m to the extraction plant.

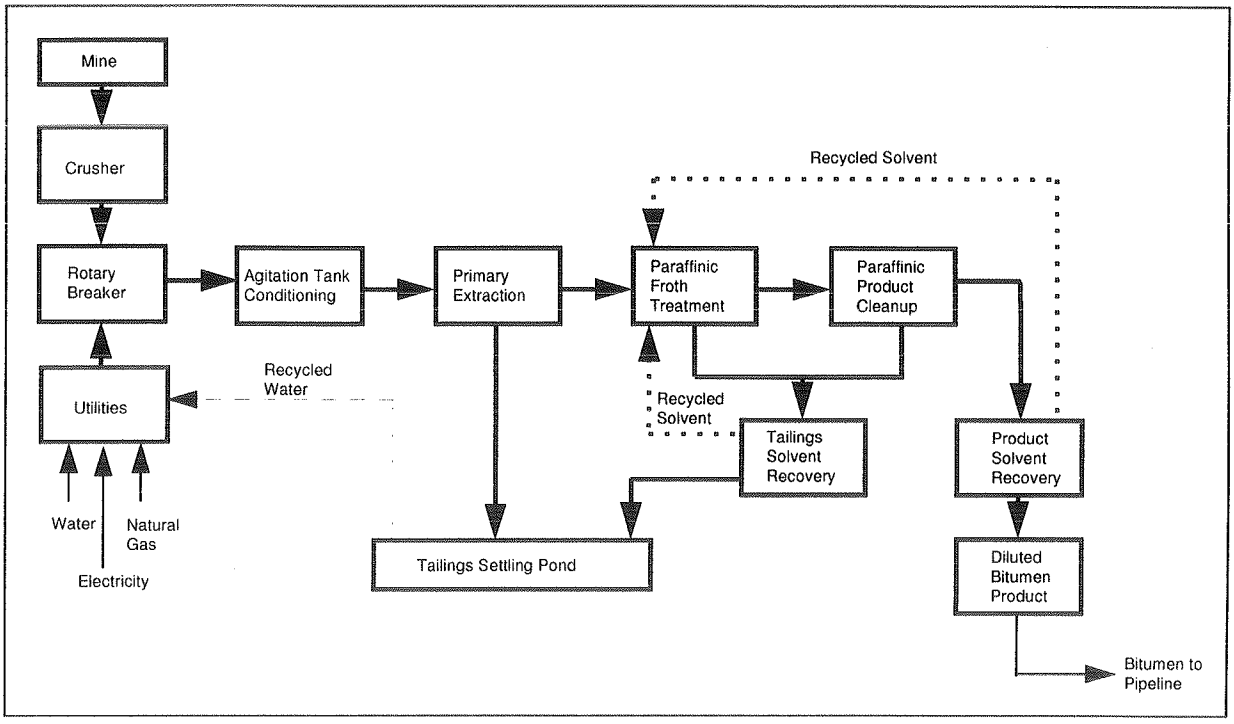

Figure 1-3: Simplified Process Schematic

EXTRACTION

Oil sands delivered from the mining operation will be further sized and conditioned for the initial phase of bitumen separation (primary extraction).

A rotary breaker (a perforated rotating drum) with hot water addition will be used to further reduce the size of the oil sands for slurry preparation. Agitation conditioning tanks will be used for conditioning the oil sands. A non-caustic extraction process, operating at temperatures between 45°C and 50°C, will be used.

From the conditioning tank, the conditioned slurry will be pumped into a surge tank before entering a conventional primary bitumen extraction unit.

The bitumen froth from the primary extraction circuit will be fed to the froth treatment process, which is required to produce a clean diluted bitumen product. The coarse sand and fine tailings products from the primary extraction process will be combined and transported as water slurry to the tailings settling pond.

Froth emulsion from the water-based oil sands bitumen extraction process must be treated to produce a bitumen product that is sufficiently free from water and solids to enable it to be upgraded or marketed directly.

The conventional froth treatment process used by the existing operators, while acceptable in meeting the feed requirements for an on-site upgrader, can present problems in meeting the water and solids specifications for commercial pipelines. The objective for the Muskeg River Mine Project is to produce a bitumen product that meets broadly accepted pipeline specifications of a 0.5 wt% basic sediment and water content (BS&W). Shell intends to upgrade the material, but wants to leave the direct marketing of bitumen option available by targeting for a premium bitumen product quality. The primary goal is to create a feed that will be optimum for Shell's upgrading options.

The Muskeg River Mine froth treatment process will use a conventional dilution centrifuging froth treatment process, but will add a product clean-up processing unit to provide final removal of ultra-fine solids and residual water. This product clean-up step involves the recently developed paraffinic solvent demulsification (PSD) process, which has been the focus of a joint industry effort through the Canadian Oilsands Network for Research and Development (CONRAD) Extraction Technology Development Group. The difference from the work undertaken through CONRAD is the use of conventional centrifuge technology to remove bulk solids and water, rather than attempting to apply the PSD process directly to a bitumen froth stream.

A key feature of the PSD process is the upgrader feed preconditioning involving the capture of the ultra-fine solids material by a small amount of a heavy, coke-like hydrocarbon material, which can be preferentially removed with the tailings. The result is that the original oil continuous emulsion (water-in-oil) separates into a dilute bitumen phase with BS&W less than 0.1 %.

The bitumen material from froth treatment will be taken to a product solvent recovery unit where the bulk of the paraffinic diluent will be removed to give a diluted bitumen with about 30% diluent by volume for pipeline transportation.

TAILINGS

The Muskeg River Mine Project intends to manage the bitumen extraction plant tailings streams economically and in a way that:

- minimizes out-of-mine impact

- allows for a stable, long-term landscape, consistent with effective reclamation and mine closure planning

In the initial four years of operation, the tailings streams from the extraction process will be pumped to a surface tailings settling pond. Clarified water from the pond will be recycled to the process. Once sufficient mining has occurred to enable a separate storage area in the mined-out pit to be segregated, the mature fine tailings from the tailings settling pond, in combination with the extraction plant streams, will be used to produce consolidated tailings for in-pit disposal.

PILOT PLANT

Shell is currently planning a pilot plant facility on Lease 13 to provide information for front-end engineering and process optimization. The scope of this pilot includes tailings handling. The pilot results, together with the ongoing development work on tailings management by the existing operators, will provide a solid design basis for implementing consolidated tailings for the Muskeg River Mine.

UTILITIES

The project will require about 80 MW of electrical power, which will be supplied from the Alberta electrical grid. Alberta Power Limited (APL) has proposed that two 144 kV power lines from APL's Ruth Lake substation or Beaver Lake substation will be needed to link the Muskeg River Mine to the Alberta electrical grid. Other options for electrical power supply, including on-site cogeneration of electricity and hot water, are being evaluated.

Extraction process heat will be provided by natural-gas-fired heaters and packaged utility boilers. Opportunities to reduce overall energy demands will be pursued during the front-end engineering and design phase in 1998.

Natural gas will be supplied through a new pipeline to the Lease 13 site. The commercial arrangements for providing this link are currently being assessed. Requirements are estimated to range from 1 million m^3/d in summer to 1.3 million m^3/d in winter (30 to 50 MMSCFD).

Auxiliary Systems

Process water will be provided through a combination of:

- muskeg surface drainage
- basal aquifer depressurization
- raw makeup water from the Athabasca River

Beginning in 2004, water will be recycled from the tailings settling pond to the process. This will reduce the volume of makeup water intake from the Athabasca

River. A new water intake facility will be required at the Athabasca River with a pipeline to the extraction plant.

Diesel fuel required for the mine operation is estimated at 65 million litres annually. This will be stored on site in tanks. Nitrogen and instrument and utility air will be supplied by conventional industrial units on site. Solid waste disposal is currently planned via an on site industrial landfill.

A camp will be developed on site to house workers for the construction period.

Facility Locations

The location of the major project facilities is shown in Figure 1-4.

The utility service corridor, with road access, natural gas pipeline, electrical power and communications is required to support the development. This will follow a common corridor north toward the Lease 13 boundary. Access to the plant will be east along the southern lease boundary, then northeast to the plant site. The east-west segment along the lease boundary might also serve other potential access needs, such as future development at Syncrude's Aurora South Mine and Mobil's Kearl Lake Project.

The diluted bitumen product and diluent pipelines will follow a corridor from the plant site southeast to the southern boundary of Lease 13, then generally follow the 1986 *Alberta Forestry Athabasca Oil Sands Multiple Use Corridor Study* route.

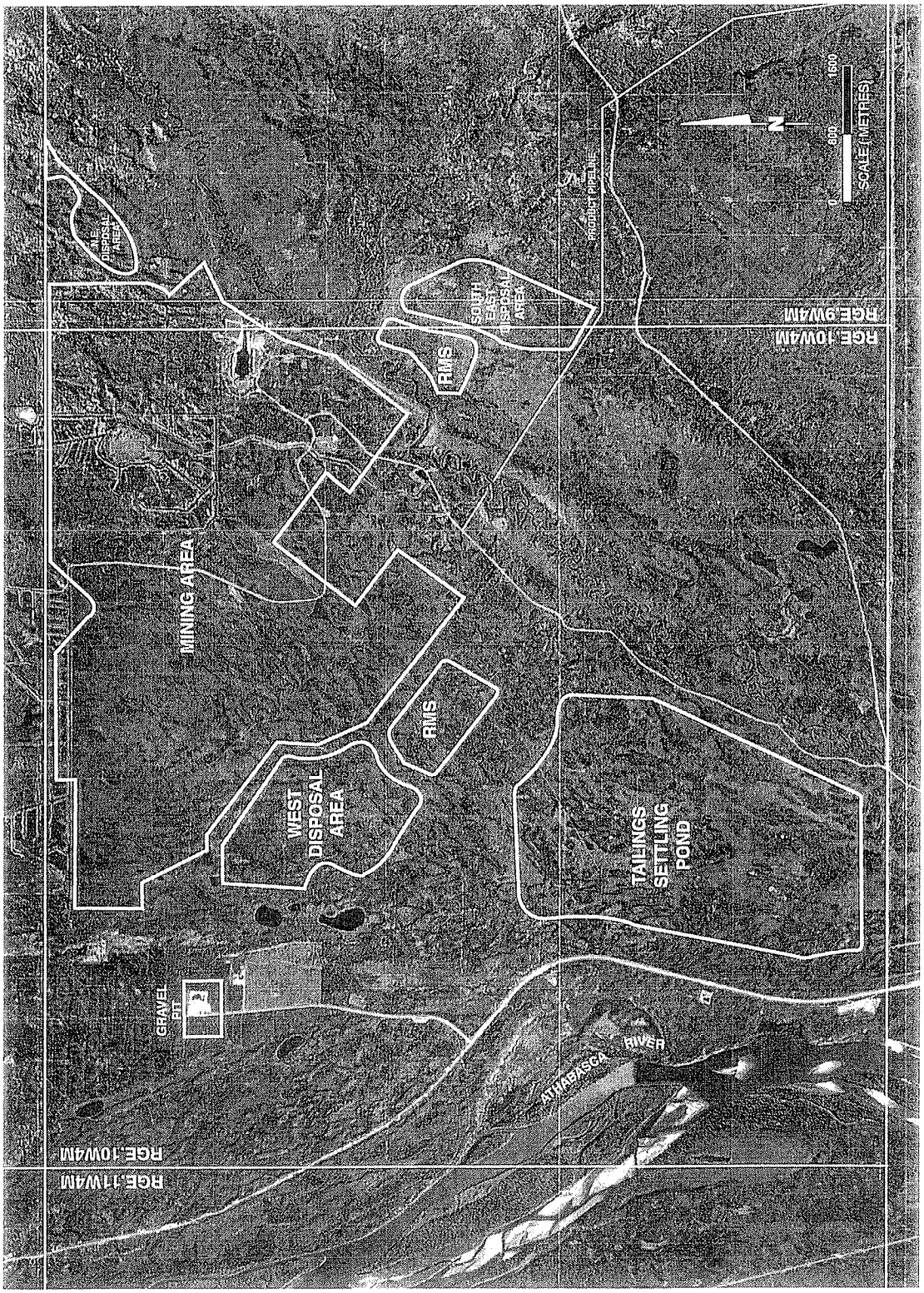

Figure 1-4: Aerial Photo of West Side of Lease 13

MUSKEG RIVER MINE PROJECT
EIA SUMMARY

OVERVIEW

INTRODUCTION

This report summarizes the basis and results of the Environmental Impact Assessment (EIA) that was conducted for the Muskeg River Mine Project (Project) on the western portion of Lease 13. The EIA cumulatively assessed the impacts associated with the development, operation and reclamation of the Project, in association with existing regional developments. The EIA also addressed the cumulative impacts associated with existing developments, the Project and newly approved developments (not fully operational). This scenario is referred to as the Cumulative Effects Assessment (CEA). Finally, a Regional Development Review (RDR) impact assessment, which included the developments associated with the CEA and publicly disclosed developments, was completed.

The impact predictions were presented in terms of direction, magnitude, frequency, duration, reversibility and geographic extent. The EIA report discussed measures to prevent or mitigate impacts, proposed monitoring programs and reviewed the residual and cumulative impacts and their significance.

For further details on the EIA, see: Volume 2 (Baseline Biophysical and Historical Resources); Volume 3 (Biophysical and Historical Resources Impact Assessment); Volume 4 (Biophysical and Historical Resources Cumulative Effects Assessment); and Volume 5 (Socio-Economics Baseline and Impact Assessment).

Results of Assessment

The predicted biophysical and historical resource impacts identified for the Muskeg River Mine Project are acceptable. The predicted impacts will have no significant long-term effects on the environment, provided the recommended mitigation is undertaken. Appendix 1 contains a summary of the mitigation measures and residual impacts associated with the EIA.

SCOPE OF THE EIA

The Environmental Impact Assessment (EIA) for the Muskeg River Mine was completed in accordance with AEP's Final Terms of Reference for the Project. Therefore, the EIA:

- predicts the biophysical and historical resource impacts that could result from the Project 's development, operation and reclamation, including their direction, magnitude, frequency, duration, reversibility and geographic extent (Appendix 1 contains a summary of the impact classification applied in the EIA);
- identifies measures to prevent or mitigate impacts, and to monitor environmental protection measures and residual and cumulative impacts;
- evaluates the residual effects of the Project; and
- outlines proposed research programs and other follow-up activities related to the proposed Project.

This section summarizes the basis and results of the biophysical and historical resources portion of the EIA. The socio-economic portion of the EIA is summarized in Section 3.

BASELINE CONDITIONS

The EIA provides information on the environmental resources and resource use that could be affected by the Project. The baseline conditions for the Project development area provide the foundation upon which biophysical and historical resources impacts were predicted. The biophysical and historical resources baseline conditions are described in EIA Volume 2.

The EIA baseline conditions represent different components of the environment:

- air quality
- hydrogeology - groundwater
- surface water hydrology
- surface water quality
- aquatic resources
- ecological land classification
- terrain and soil
- terrestrial vegetation
- wetlands
- wildlife
- human health
- historical resources
- traditional land use
- resource use

Included within each baseline discussion is a review of the information available from the literature, previous oil sands EIA reports and environmental studies. Additional information from current oil sands operations, industry study groups, traditional knowledge and government sources was also used in the baseline. The final source of baseline information for the Project came from studies completed in 1997 as part of the Muskeg River Mine Project EIA.

LOCAL AND REGIONAL CONSIDERATIONS

The information on baseline conditions collected for the EIA included considering local (Figure 2-1) and regional (Figure 2-2) study areas (LSA and RSA). The LSAs centered around the Project development area on the western portion of Lease 13. The RSA area extended from south of Fort McMurray, north toward Lake Athabasca.

IMPACT ASSESSMENT

The impact assessments of environmental, historical resource and socio-economics were focused on issues identified by regulatory agencies, local communities and other oil sands development stakeholders. The impact assessments considered Project construction, operation and closure phases.

Cumulative impacts related to the Project were assessed after considering the residual impacts associated with Project in combination with three development scenarios (Table 2-1). These scenarios included:

Impact Assessment of the Project

The first scenario centers around the baseline condition (which includes the current environmental and socio-economic conditions within the project region), with the addition of the Muskeg River Mine Project to that condition.

Mitigation and monitoring programs are reviewed under this development scenario. Such programs were not discussed under the two other development scenarios because the operators of those developments may propose and be subject to unique solutions and requirements, depending on circumstances specific to their developments.

Cumulative Effects Assessment

The second assessment scenario is referred to as the Muskeg River Mine Cumulative Effects Assessment (CEA). This scenario considers the potential impacts of the Project, plus the existing developments (i.e., the current baseline) plus currently approved oil sands developments within the RSA.

Regional Development Review

The third assessment scenario is referred to as the Regional Development Review (RDR). This assessment considers the potential impacts of developments included in the CEA, plus publicly disclosed developments within in the RSA.

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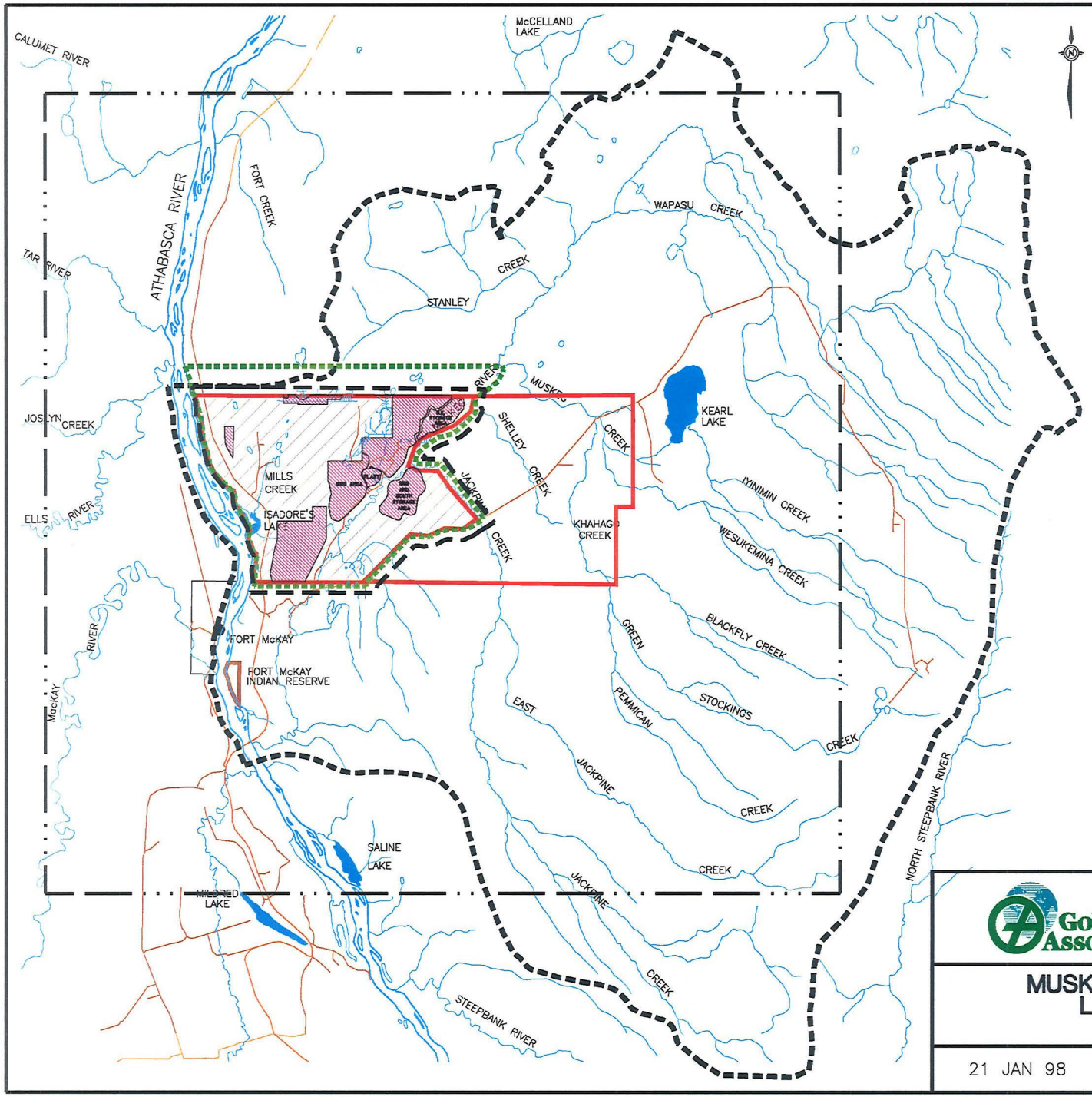

LEGEND

- LEASE 13
- MUSKEG RIVER MINE PROJECT DEVELOPMENT AREA

LOCAL STUDY AREAS (LSAs)

- AIR QUALITY AREA
- AQUATICS – SURFACE WATER HYDROLOGY, SURFACE WATER QUALITY AND AQUATIC RESOURCES
- HYDROGEOLOGY (GROUNDWATER)
- TERRESTRIAL – TERRAIN AND SOILS, TERRESTRIAL VEGETATION, WETLANDS, WILDLIFE, ECOLOGICAL LAND CLASSIFICATION
- HISTORICAL RESOURCES, 1997 FOCUS AREAS

NOTE

HUMAN HEALTH – COMBINATION OF AIR QUALITY AND AQUATIC LSAs

TRADITIONAL LAND USE AND RESOURCE USE – COMBINATION OF TERRESTRIAL AND AQUATIC LSAs

REFERENCE

DIGITAL DATA SETS 74D, 74E, 74I
84A AND 84H FROM RESOURCE DATA DIVISION
ALBERTA ENVIRONMENTAL PROTECTION, 1997.

0 5 10 15km

SCALE 1:300,000

Golder Associates

SHELL CANADA LIMITED

MUSKEG RIVER MINE PROJECT
LOCAL STUDY AREAS

21 JAN 98	Figure 2–1	DRAWN BY: VS/TM

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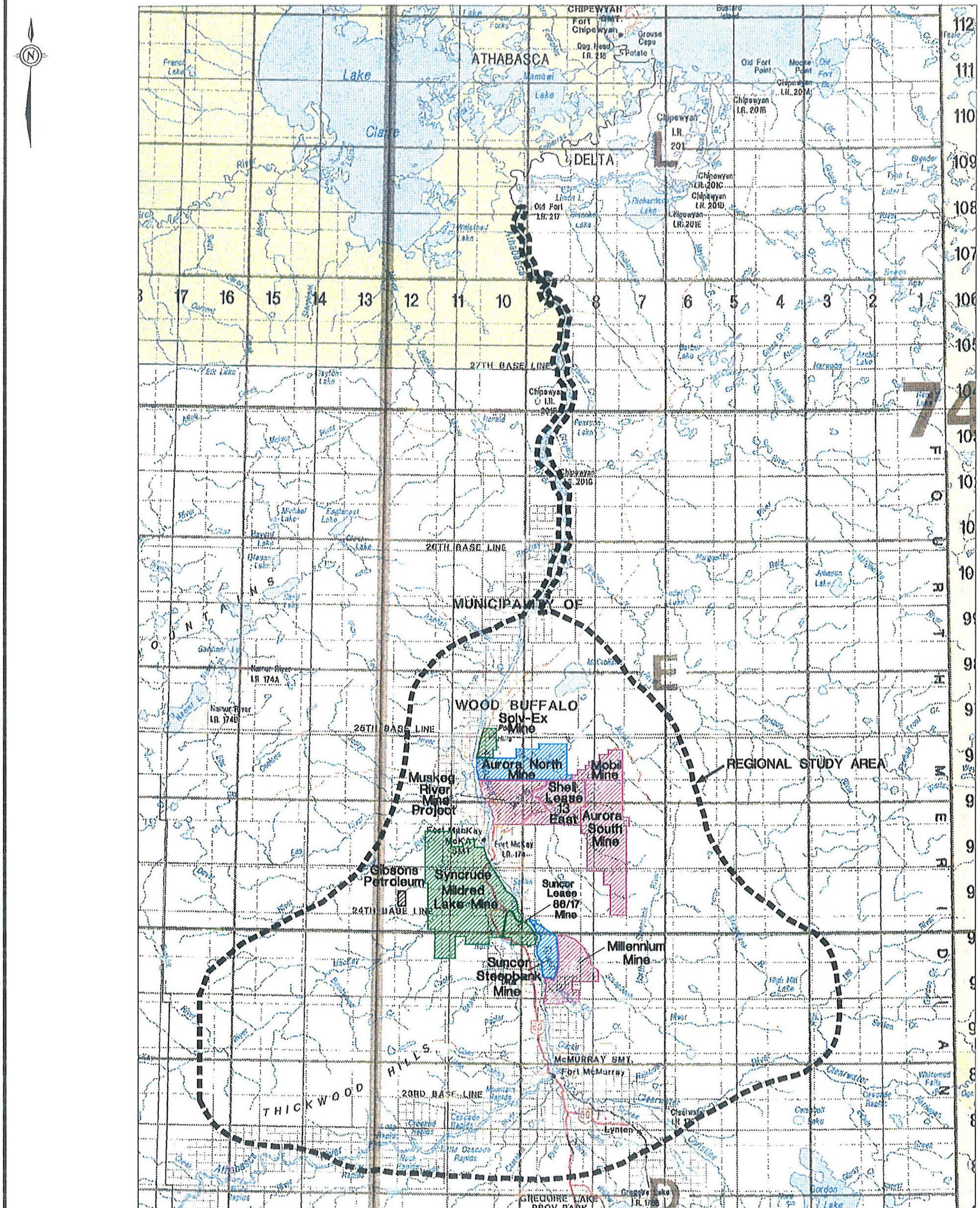

0 10 20 30 40 50km

SCALE 1:1,250,000 (Approx.)

REFERENCE

SCANNED IMAGE OF ALBERTA ENVIRONMENTAL PROTECTION PROVINCIAL BASE MAP 1997, ORIGINAL SCALE 1:1,000,000

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REGIONAL STUDY AREA

1 DEC 97	Figure 2 - 2	DRAWN BY: TM

Table 2-1 Regional Development Impact Scenarios in the RSA

DEVELOPMENT	Section D Environmental Baseline	Section E Impact Assessment	Section F Cumulative Effects Assessment	Section G Regional Development Review
	BASELINE Conditions to the end of 1997	**BASELINE + *Muskeg River Mine Project***	**BASELINE + Muskeg River Mine Project + *APPROVED DEVELOPMENTS***	**BASELINE + Muskeg River Mine Project + Approved Developments + *PUBLICLY DISCLOSED DEVELOPMENTS***
EXISTING	**Suncor Lease 86/17**	Suncor Lease 86/17	Suncor Lease 86/17	Suncor Lease 86/17
	Syncrude Mildred Lake	Syncrude Mildred Lake	Syncrude Mildred Lake	Syncrude Mildred Lake
	Suncor Steepbank	Suncor Steepbank	Suncor Steepbank	Suncor Steepbank
	Gibsons Petroleum	Gibsons Petroleum	Gibsons Petroleum	Gibsons Petroleum
	SOLV-EX	SOLV-EX	SOLV-EX	SOLV-EX
	Municipalities	Municipalities	Municipalities	Municipalities
	Pulp mills for water quality	Pulp mills for water quality	Pulp mills for water quality	Pulp mills for water quality
	Forestry	Forestry	Forestry	Forestry
	Pipelines/roadways/ others	Pipelines/roadways/ others	Pipelines/roadways/ others	Pipelines/roadways/others
THE PROJECT		**Muskeg River Mine Project**	Muskeg River Mine Project	Muskeg River Mine Project
APPROVED			**Syncrude Aurora North and South Mines**	Syncrude Aurora North and South Mines
			Suncor Steepbank Mine and Fixed Plant Expansion	Suncor Steepbank Mine and Fixed Plant Expansion
			Forestry	Forestry
DISCLOSED				**Suncor Project Millennium - Upgrader and Mine**
				Shell Lease 13 East Mine
				Syncrude Project 21 Mildred Lake Upgrader Expansion
				Mobil Kearl Mine and Upgrader
				Petro-Canada MacKay River - In-situ
				JACOS Hangingstone - In-situ
				Gulf Surmont - In-situ
				Major pipelines, utility corridors and roadways

AIR QUALITY IMPACTS

Scope of Assessment

The impact assessment for air quality considered the potential effects from the developments, where applicable, on: exceedance of ambient concentration guidelines; human health effects due to air emissions; acidification potential; photochemical production of ozone; and greenhouse gases.

Impact Assessment of the Project

The maximum ambient nitrogen dioxide (NO_2) and particulate matter (PM_{10}) concentrations will be less than the ambient air quality guidelines. The primary deposition of acid-forming precursors is predicted to result from the dry deposition of NO_2 from the mine fleet. Potential acid input (PAI) values in excess of the 0.25 keq/ha/a target loading for sensitive ecosystems are predicted for a small area in the vicinity of the Project.

There is the potential for ozone concentrations to exceed provincial guidelines for limited periods at some locations during the summer. This is primarily because naturally occurring ozone concentrations already reach or exceed the guidelines.

Mitigation

Mitigation strategies to reduce oxide of nitrogen (NO_x) emissions include selecting:

- low NO_x burners for the plant site
- mine fleet vehicles with emission control technology

The tailings solvent recovery unit will reduce volatile organic compound (VOC) and total reduced sulphur (TRS) losses to the tailings settling pond. A vapour control system will reduce VOC and TRS emissions from the solvent and product storage tanks.

PM emissions during site clearing will be reduced by controlled burning procedures. Fugitive PM emissions during operation of the mine will be controlled through road maintenance, such as watering in dry weather, and progressive reclamation activities.

Energy efficiency objectives, such as an optimized mine plan for minimizing material handling and travel distances, coupled with a warm water extraction process, will help manage carbon dioxide (CO_2) emissions.

Monitoring

Source monitoring for the Project will include:

- the ongoing estimation of NO_x and CO_2 emissions
- periodic monitoring to assess fugitive PM and VOC emissions

Ambient monitoring will include a single trailer to measure NO_2 and PM_{10} in the vicinity of the mine. Participation in the Wood Buffalo Zone airshed monitoring program will address regular monitoring needs.

Cumulative Effects Assessment

Maximum concentrations of emissions associated with mine pits and secondary combustion sources will occur close to the respective development areas (typically a few kilometres or less).

The CEA scenario will increase the area where the 0.25 keq/ha/a potential acid input (PAI) value is exceeded, from approximately 1,800 to 2,500 km^2. An additional 10 ppb maximum ozone concentration over the base case would still enable the 82 ppb guideline to be achieved.

Regional Development Review

The RDR scenario will increase the region where the 0.25 keq/ha/a PAI value is exceeded from 2,500 to 4,000 km^2. The continued increase in NO_x and VOC indicates a potential for ozone formation in the RSA due to precursor emissions. Under conditions favorable for the formation of ozone, there is the potential for the hourly guideline of 82 ppb to be exceeded. Shell, Syncrude and Suncor have recently initiated a program to model regional ground level ozone using a model expected to more accurately predict ozone concentrations.

HYDROGEOLOGY - GROUNDWATER IMPACTS

Scope of Assessment

The hydrogeology - groundwater impact assessment predicted the effects of the three development scenarios on:

- local and regional groundwater systems;
- groundwater quality; and
- re-establishment of groundwater systems following closure of the Project.

The groundwater impact assessment considered the potential influence of the Project and other developments on water levels in area lakes, including Kearl Lake, McClelland Lake and Isadore's Lake, as well as on the Muskeg and Athabasca rivers.

Impact Assessment of the Project

Groundwater levels and flow patterns will be altered from their natural state only in the local study area. The impact is acceptable, given that the effect is reversible after mining is completed.

Groundwater quality in the Basal Aquifer beneath the mine and tailings settling pond, in the oil sands and lean oil sands, possibly surficial sediments to the east of the pond, and on both sides of the tailings settling pond will be altered in varying degrees from their natural state. The impact on groundwater quality in the LSA will be long term. The change in water quality is not significant.

Mitigation

Mitigation strategies to minimize potential impacts on groundwater resources include constructing a ditch around the tailings settling pond.

Monitoring

Monitoring wells will be located by the mine pits and reclaimed tailings structure to identify any changes or trends in groundwater quality. Wells will also be installed to monitor the performance of the overburden dewatering and Basal Aquifer systems as well as to monitor the magnitude of drawdown in the adjacent unmined overburden and Basal Aquifer areas.

Cumulative Effects Assessment

The cumulative impacts on Kearl Lake from drawdown, due to depressurization of the Basal Aquifer, are such that downward seepage from the lake will increase over both natural rates and the rate associated only with the Muskeg River Mine Project. This impact is not expected to extend to McClelland Lake. The complete recovery of groundwater levels in the Basal Aquifer is likely to take up to 30 years after completion of mining, however, groundwater levels will eventually recover. Therefore, the effects on Kearl Lake are reversible. Overall, the degree of concern related to cumulative effects of Basal Aquifer drawdown due to depressurization is considered to be low.

Regional Development Review

The residual impacts and degree of concern, considering proposed regional developments, is the same as for the cumulative effects assessment.

SURFACE WATER HYDROLOGY

Scope of Assessment

The surface water hydrology impact assessment predicted the effects of the three development scenarios on receiving and nearby waterbodies, including streams, lakes, ponds and wetlands. The potential effects were evaluated in terms of:

- changes in flows and water levels in water bodies;
- changes in basin sediment yields and sediment concentrations in water bodies;
- changes in the regime or geomorphic condition of receiving streams;
- changes in open-water areas; and
- sustainability of reclaimed landscape and reclamation drainage systems.

Impact Assessment of the Project

The Project will have a negligible effect on the:

- flows and water levels in the Athabasca River, Isadore's Lake and Kearl Lake; and
- channel regimes of both Mills Creek and the Muskeg River.

The project will cause a negligible to small increase in sediment concentrations in Mills Creek and the Muskeg River.

The Project will have negligible effects on the flows and water levels in the Muskeg River and Mills Creek during construction and for most of the time during operation. It will moderately increase the Muskeg River flows for two years during the end pit lake management period, and moderately increase the Mills Creek flows during the period of muskeg drainage and overburden dewatering discharge to the creek. The Project will moderately reduce the Mills Creek flows after closure, but it will have only a small effect on the Muskeg River flows after closure.

The reclaimed landscape and drainage systems will provide larger open-water areas of streams, wetlands and lakes, replacing the open-water areas lost during construction and operation. A feasible, conceptual reclamation drainage plan was developed to design and predict long-term sustainability of the closure reclamation landscape and drainage systems.

Mitigation

In addition to following regulatory guidelines and best management practices, mitigation measures to minimize impacts on the surface water hydrology include:

- using tailings porewater releases, Basal Aquifer water and process-affected water to reduce raw water withdrawal from the Athabasca River;
- distributing muskeg drainage and overburden dewatering activities evenly throughout the development life to avoid a large increase in flows to receiving streams;
- routing drainage water and runoff from cleared areas to polishing ponds where sediments will settle before water discharge to receiving streams;
- providing erosion protection measures;
- reducing sediment loadings to receiving streams during construction of access roads and stream crossings; and
- developing a sustainable closure landscape and drainage systems by:
    - vegetating reclaimed surfaces to minimize surface erosion,
    - building drainage networks and regime channels to minimize gully and channel erosion, and
    - constructing wetlands and lakes to reduce flood peak discharges and sediment loadings to receiving streams.

Monitoring

The impacts on surface water hydrology will be monitored by:

- monitoring flows, water levels and sediment concentrations at the Alsands Drain, Muskeg River, Mills Creek and Isadore's Lake; and
- participating in the Regional Hydrology Program.

Cumulative Effects Assessment

Combined developments associated with the CEA scenario will have negligible effects on the flows and water levels in Athabasca River both during operation and in the far future.

The combined developments will cause a small increase in sediment concentrations in the Muskeg River during operation, but will have negligible effects on channel erosion of the Muskeg River. Negligible increases in sediment concentrations and negligible increases in channel erosion will occur in the far future.

The reclaimed landscape and drainage systems will provide larger open-water areas of streams, wetlands and lakes, thus replacing the open-water areas lost during construction and operation.

The combined developments will cause small to moderate increases in the Muskeg River flows during the Project's operation and end pit lake management period. The combined developments will have only a small effect on the Muskeg River flows after closure.

Regional Development Review

The findings of the RDR are similar to the CEA scenario, except the developments will cause a small, instead of negligible, decrease in the flows and water levels in Athabasca River during operation. Negligible effects are projected for the far future.

SURFACE WATER QUALITY

Scope of Assessment

The surface water quality impact assessment predicted the effects of the three development scenarios, where applicable, on:

- compliance with water quality guidelines in the Athabasca and Muskeg rivers;
- compliance with toxicity guidelines in the Athabasca and Muskeg rivers;

- changes in water temperature of the Muskeg River from operational and reclamation water releases;
- changes in the dissolved oxygen levels in the Muskeg River from muskeg and overburden dewatering activities;
- accumulation of polycyclic aromatic hydrocarbons (PAHs) from operational and reclamation water releases in sediments in the Muskeg River;
- compliance with toxicity guidelines in the end pit lake prior to water discharge to the Muskeg River;
- accidental releases occurring and affecting the water quality of the Muskeg and Athabasca rivers; and
- changes in water quality from acidifying emissions.

Impact Assessment of the Project

The Project, in combination with existing developments in the LSA or RSA, will not cause exceedance of toxicity guidelines for aquatic life. Although several metals exceed water quality guidelines in the Muskeg and Athabasca rivers, the majority are due to natural background occurrences of these metals. These metals are not considered to be of concern, because they are associated with suspended particulate matter and are thus not in a bioavailable form. Exceedances of human health water quality for two PAH compounds were predicted to occur during initial end pit lake discharges. Follow-up human health risk analysis rejected these compounds as being of concern to wildlife and human health. Strategic design and management of discharges into the end pit lake will enable acute and chronic toxicity guidelines to be met before the outflow from the end pit lake reaches the Muskeg River.

It was concluded that the potential for accidental releases would be effectively minimized by implementing design features and appropriate training.

Temperature fluctuations in the Muskeg River, as a result of changing flow regimes, would remain within acceptable ranges. Dissolved oxygen impacts from muskeg drainage waters are not expected to occur. The accumulation of PAHs on sediments is not expected to occur, because of limited available pathways. Acidification of waterbodies as a result of air emissions is unlikely, although questions remain about possible spring runoff acidification.

Mitigation

Mitigation strategies to minimize impacts include:

- constructing a ditch around the tailings settling pond;
- timing the release of the end pit lake discharges, to such as open water periods, for the first few years of discharge;

- depositing consolidated tailings (CT) below ground level to minimize seepage; and
- developing wetlands systems on the reclaimed tailings settling pond and CT deposits to provide retention and bioremediation of process-affected waters.

Monitoring

Monitoring programs will include:

- evaluating the muskeg drainage and sedimentation ponds for dissolved oxygen concentrations;
- monitoring the end pit lake for PAHs and other constituents; and
- participating in the Regional Aquatic Monitoring Program (RAMP).

Cumulative Effects Assessment

Exceedances of toxicity guidelines for aquatic life are not predicted under the CEA scenario. There are two additional water quality guideline exceedances in the Athabasca River (benzo(a)anthracene at mean open-water flow and iron at 7Q10 flow). However, follow-up risk analysis in Section F11 and Section F12 did not identify these substances as a concern to wildlife or human health. No additional increases were predicted in levels of substances that exceeded guidelines in the Project Impact Assessment. In the Muskeg River, levels of nearly all substances that exceeded guidelines previously increased at both modelled flows, with six new substances predicted to exceed guidelines at 7Q10 flow. The additional developments included in the CEA will have a greater effect on the Muskeg River than on the Athabasca River, which reflects the different dilution capacities of these rivers. The degree of concern associated with these exceedances is negligible.

Greater temperature declines were predicted during the open-water season and the potential for slower seasonal warming and cooling is greater than predicted previously. However, the regulatory guideline for temperature is not predicted to be exceeded.

Due to the qualitative nature of the analysis, it is not possible to estimate differences in sediment polycyclic aromatic hydrocarbon (PAH) levels between the Impact Assessment and the CEA. Since pathways for PAHs to leave oil sands developments are limited, an impact on sediment PAH levels is unlikely.

The area affected by deposition of acidifying substances is greater than that identified during the Project Impact Assessment. This suggests that spring pH depression in sensitive waterbodies is a potentially important impact of combined developments in the RSA.

Regional Development Review

Concentrations of most substances exceeding guidelines in the RDR are identical to, or slightly higher than predicted concentrations in the CEA. Temperature declines predicted in the RDR are slightly greater than identified for the CEA, but remain below the guideline. The size of the area with potential spring pH depression in sensitive waterbodies is slightly larger for the RDR than that predicted for the CEA.

AQUATIC RESOURCES

Scope of Assessment

The aquatic resources impact assessment predicted the effects of the three development scenarios, where applicable, on:

- changes in fish habitat because of changes in flows in watercourses, thermal regime, direct losses, effects on spawning habitat, increased erosion, changes in stream morphology and increases in suspended solids in streams;
- acute and chronic effects on fish through releases of operational and reclamation waters;
- changes in the quality of fish flesh; and
- abundance of fish.

The impact assessment also considered the potential for the Muskeg River Mine Project's end pit lake to support a viable aquatic ecosystem.

Impact Assessment of the Project

The Project, in combination with existing developments in the local or regional study areas, is not expected to cause tainting or bioaccumulation of chemicals in fish tissue, or acute and chronic effects on fish.

No habitat for sports fish will be disturbed during the life of the Project or after closure. A small amount (1.7%) of available forage fish habitat in the LSA will be disturbed during construction and operations, but it will be replaced through reclamation. At closure, the reclamation drainage system, which consists of wetlands, streams and an end pit lake, will provide additional habitat for sports and forage fish.

Mitigation

Mitigation strategies to minimize effects on aquatic resources include those summarized in surface water hydrology and surface water quality, for example:

- using tailings porewater releases, Basal Aquifer water and process-affected water for operational waters, to reduce raw water withdrawal from the Athabasca River;
- distributing muskeg drainage and overburden dewatering evenly throughout the life of the mine to avoid a large increase in flows to receiving streams;
- routing drainage water and runoff from cleared areas to polishing ponds, to settle sediments before discharging to receiving streams;
- providing erosion protection measures;
- reducing sediment loadings to receiving streams during construction of access roads and stream crossings;
- developing a sustainable closure landscape and drainage systems by:
  - vegetating reclaimed surfaces to minimize surface erosion,
  - building drainage networks and regime channels to minimize gully and channel erosion, and
  - constructing wetlands and lakes to reduce flood peak discharges and sediment loadings to receiving streams;
- constructing a ditch around the tailings settling pond to collect seepages;
- timing the release of the end pit lake discharges, such as to open water periods, for the first few years of discharge;
- depositing CT below ground level to minimize seepage; and
- developing wetlands systems on the reclaimed tailings settling pond and CT deposits to provide retention and bioremediation of operational and reclamation waters.

Design features for preventing or minimizing sediment loading, changes in dissolved oxygen, water temperature fluctuations and water quality changes will minimize effects on aquatic resources. Effects on critical sports fish habitat will be avoided by setting Project facilities back at least 100 m from the Muskeg River and Jackpine Creek.

Monitoring

Benthic invertebrates will be monitored, in conjunction with water quality monitoring, to assess the effects on aquatic resources from the end pit lake discharge.

All other monitoring for the Muskeg and Athabasca rivers will be done as part of the RAMP, which will include monitoring for bioaccumulation in fish tissue, water quality, benthic invertebrates and fish populations.

Cumulative Effects Assessment

No tainting or accumulation of chemicals in fish are predicted as a result of combined developments. Neither are acute and chronic effects on fish expected. No effects on fish habitat in the Athabasca River are expected.

Negligible to Low effects on northern pike and Arctic grayling habitat in the Muskeg River are predicted due to predicted changes in flows and water temperature. Low effects on forage fish habitat are predicted in the RSA for the life of the developments. At each stage in the developments, habitat disturbed will be replaced with habitat of equivalent or better productivity. Habitat replaced through reclamation will result in a net gain in habitat for both forage and sport fish in the Far Future.

Regional Development Review

The results of the RDR for aquatic resources are the same as for the CEA.

TERRESTRIAL RESOURCE IMPACTS

Scope of Assessment

The terrestrial resources impact assessment included considering the Project's effects on terrain and soils, terrestrial vegetation, wetlands, ecological land classification units and wildlife. The impact assessment focused on the:

- loss or alteration of terrain and soils, vegetation communities and wetlands;
- changes in soils, vegetation communities or wetlands because of air emissions or water releases;
- changes in biodiversity;
- changes in wildlife habitat; and
- impacts to wildlife health caused by air emissions or water releases.

The impact assessment also considered the potential for landscape reclamation and closure activities to replace terrain, soils, vegetation, wetlands and wildlife habitat.

Impact Assessment of the Project

Terrestrial resources within the LSA will be significantly disrupted by the activities associated with construction and operation of the development. Wildlife will be displaced, vegetation communities will be disrupted and biodiversity will decline.

However, these effects will be localized and, for the most part, will be reversible. On reclamation and closure of the development, self-sustaining vegetation communities will evolve to productive ecosystems similar to those existing pre-development.

The Project, in combination with existing developments in the RSA, is not expected to have an adverse affect on wildlife or human health from ingesting water, aquatic prey or plants during the operation or after mine closure.

Mitigation

During the construction and operation of the Project, the terrain, soils and vegetation will be temporarily disturbed. About 40% of the LSA will be affected. However, the phased mine development plan will result in mine construction and reclamation proceeding in sequence, to minimize the amount of disturbed land at any one time.

Wildlife habitat will be progressively altered during the mine construction phases. Clearing and reclamation will be phased to minimize the area of habitat disturbed at any one time. Major activities adjacent to the Athabasca and Muskeg rivers will be completed outside the critical winter period, consistent with Alberta Fish and Wildlife guidelines. Wetlands habitat will be affected the most. However, the disturbed areas will be reclaimed to produce a mosaic of landforms and early to middle successional vegetation types. The increase in better-drained habitat will improve habitat for some species, such as moose and western tanager, but will be less favourable for species such as beaver.

Landforms will be altered to allow access to the oil sands ore, resulting in the removal of overburden and reclamation materials that will be stored on site. The reclamation materials and some of the overburden will be reused during reclamation to provide a variety of landscapes, topography and slope conditions. The landforms re-established in the development area will be similar to pre-existing landforms, but with an overall increase in the amount of better-drained land. Some new landforms will also be created during land reclamation, such as an end pit lake, the overburden disposal areas and the reclaimed tailings settling pond area.

Land capabilities might be temporarily decreased through soil mixing, burial, compaction, erosion and temporary storage. In the poorly-drained areas of the LSA, dewatering of soils in preparation for mine development will affect Organic and Gleysolic soils. Although the natural soil conditions will be permanently altered, the reclaimed soils will have a higher capability for a variety of end land uses, such as commercial forestry and wildlife habitat.

A significant loss of the existing vegetation communities will occur within the LSA, primarily as a result of site clearing and mine dewatering. Wetlands vegetation, such as fens and bogs, will be the most affected, with lesser impacts on upland

vegetation, such as jack pine, aspen and white spruce dominated communities. Following reclamation, there will be an overall increase of commercial forest lands within the LSA (e.g., aspen-white spruce communities). The effects on old growth forests and plants used for traditional purposes is expected to be minimal. A total of three rare plants that were found throughout the LSA are known to be directly affected by the Project.

Biodiversity will be temporarily reduced during construction and operation of the Project. However, phased reclamation and the re-establishment of vegetation communities on a variety of reclaimed landscapes will provide the basis for a functionally diverse reclaimed landscape.

Monitoring

The impact of air emissions (primarily NO_x) on soils and vegetation are expected to cause localized effects immediately around the plant site. The existing environmental effects monitoring program, part of the Regional Airshed Monitoring Plan of RACQQ, will evaluate the impacts of air emissions on vegetation.

During the excavation of muskeg for direct placement on reclamation sites or salvaging for future reclamation use, monitoring will take place to ensure that the correct amount of overstripping is taking place. When the reclamation site has been revegetated, monitoring will take place to document the development of the reclamation soils and the extent of vegetation cover. The established growth of trees and shrubs will also be monitored. CT deposits will form much of the new landforms. The impact of CT release water on vegetation and soils will be monitored.

Cumulative Effects Assessment

In the regional context, the terrestrial LSA comprises approximately 1% of the RSA. Within the RSA, approximately 0.4% will be developed by the Project.

Since single macroterrain unit will be completely removed, the overall biodiversity at the macroterrain level will not be significantly altered. Soils and terrain that would be lost due the developments will be replaced with analogous forms. As a result of these developments, lands that have been rated as permanently or currently non-productive will be replaced with soils rated as low to moderate productivity.

Given the potential high level of imprecision in evaluating the acidifying emission and soil acidification linkages it was difficult to define residual impacts in a quantitative manner.

While there will be a loss of vegetative cover as a result of developing these projects, the loss will be offset through the reclamation programs. The residual impact on changes in biodiversity of terrestrial communities is low. The effects of air emissions on vegetative health in the RSA is expected to be of low concern. While fens represent approximately 65% of the RSA, the loss of bogs and fens for these developments is small (1.5%).

Although habitat loss was rated as moderate at the local level during operational stages, Shell intends to reclaim to equivalent or better habitat. This will result in an increase in habitat for upland species, e.g., moose and a decrease in habitat availability for wetland species, e.g., beavers. Effects on wildlife health due to changes to water, aquatic prey and plant quality was rated a Moderate degree of concern.

Regional Development Review

In reviewing the impacts on a regional development scale, planned projects were added to the existing and approved projects. The conclusions noted above are also directly applicable to those reached under the RDR evaluation.

HUMAN HEALTH IMPACTS

Scope of Assessment

The human health impact assessment included considering the effects of the Project on humans from:

- water releases;
- air emissions;
- consumption of local plants and animals;
- combined exposures to water releases, air emissions, plants and animals;
- working at the plant during Project construction and operation;
- noise from the Project operation; and
- releases of chemicals from the reclaimed landscape.

Impact Assessment of the Project

The Project will not result in unacceptable chemical exposures for people who live or work in the area of the Project. This conclusion is based on a conservative analysis of predicted exposures that might arise from:

- contacting or ingesting surface waters;

- ingesting local plants and animals; and
- inhaling airborne chemicals.

Because of a lack of chronic toxicity data for mammals, no conclusion could be reached on the potential exposure to naphthenic acids in surface water. However, limited acute toxicity data and subchronic toxicity data suggest that this group of chemicals is low in toxicity. Efforts within the oil sands industry are currently underway to collect new toxicity data and resolve this uncertainty.

The assessment of potential effects on humans from noise generated from the Project showed that the relative distance from the Project to area residents, combined with measures to attenuate noise will minimize effects.

Mitigation

Mitigating chemical exposures potentially arising from chemical releases to surface waters will involve activities previously identified in the surface water quality section, including:

- constructing a ditch around the tailings settling pond;
- maintaining and enhancing the perimeter ditch system with wetlands at closure;
- timing the release of the end-pit lake discharges, such as to open water periods, for the first few years of discharge;
- depositing consolidated tailings below ground level to minimize seepage; and
- developing wetlands systems on the reclaimed tailings settling pond and CT deposits to provide retention and bioremediation of process-affected streams.

Chemical exposures arising from air emissions will be mitigated by the same measures as for air quality, i.e., reducing NO_x emissions by:

- selecting low NO_x burners for the plant site; and
- equipping mine fleet vehicles with emission control technology.

The tailings solvent recovery unit will reduce VOC and TRS losses to the tailings settling pond. A vapour control system will reduce VOC and TRS emissions from the solvent and product storage tanks.

PM emissions during site clearing will be reduced by controlled burning procedures. Fugitive PM emissions during operation of the mine will be controlled through road maintenance, such as watering in dry weather, and progressive reclamation activities.

Monitoring

Monitoring includes:

- monitoring water, plants and animal tissue residues to validate estimated exposures and health risks, and how they might vary spatially and temporally; and
- monitoring air quality, including conventional parameters, organic substances, odour detection and $PM_{10}/PM_{2.5}$ at various regional nodes to validate estimated exposures and health risks, and how they vary spatially and temporally.

Cumulative Effects Assessment

No impacts to human health are predicted due to exposure to the Athabasca and Muskeg river waters.

Air emissions from vehicle fleet exhaust and VOCs from tailings settling ponds and mine surfaces for the combined developments could potentially increase the air concentrations predicted for Fort McMurray, Fort McKay and Fort Chipewyan, but the concentrations are expected to be well within the guidelines or acceptable limits. The resulting exposure ratios for the CEA, which do not differ significantly from those derived for Project Impact Assessment, are within acceptable levels.

Increased air emissions from regional developments may contribute to human inhalation exposure and chemical concentrations in plant tissues. However, there are currently no data available to evaluate this question further.

While the magnitude of chemical exposures to individuals living on reclaimed landscapes is not likely to increase due to combined developments, because of the larger area of reclaimed landscapes in the region, this exposure pathway is more likely to be realized.

It was inferred from other investigations that there is a potential for elevated noise levels to result in Fort McKay and the likelihood will increase with the added contribution of other regional developments. However, given the mobile nature of the noise sources and the capability to mitigate the noise levels through management of activities and/or use of noise barriers, the degree of concern was ranked as low.

Regional Development Review

No impacts to human health are predicted due to exposure to Muskeg and Athabasca river waters as a result of additional developments associated with the RDR.

The air emissions from vehicle fleet exhaust and VOCs from settling ponds and mine surfaces for the combined developments could potentially increase the air concentrations predicted for Fort McMurray, Fort Chipewyan and Fort McKay, but the concentrations are expected to be well within the guidelines or acceptable limits. The resulting exposure ratios for the RDR scenario do not differ significantly from those derived for the CEA and the Project Impact Assessment scenarios and are within acceptable levels.

As indicated in the CEA, further increased air emissions from regional developments may contribute to human inhalation and exposure as well as chemical concentrations in plant tissues. However, there are currently no data available to evaluate this question further.

While the magnitude of chemical exposures to individuals living on reclaimed landscapes is not likely to increase due to combined developments, because of the larger area of reclaimed landscapes in the region, this exposure pathway is more likely to be realized.

It was inferred from other investigations that there is potential for elevated noise levels to result in Fort McKay and the likelihood will increase with the added contribution of approved and planned developments. However, given the mobile nature of the noise sources and the capability to mitigate the noise levels through management of activities and/or use of noise barriers, the degree of concern was ranked as low.

As indicated in the CEA, further increased air emissions from regional developments may contribute to human inhalation and exposure and chemical concentrations in plant tissues. However, there are currently no data available to evaluate this question further.

While the magnitude of chemical exposures to individuals living on reclaimed landscapes is not likely to increase due to combined developments, due to the larger area of reclaimed landscapes in the region, this exposure pathway is more likely to be realized.

It was inferred from other investigations that there is potential for elevated noise levels to result in Fort McKay and the likelihood will increase with the added contribution of approved and planned developments. However, given the mobile nature of the noise sources and the ability to mitigate the noise levels through management of activities and/or use of noise barriers, the degree of concern was ranked as low.

TRADITIONAL LAND USE AND NON-TRADITIONAL RESOURCE USE

Scope of Assessment

The assessment of the Project's effects on traditional land use and non-traditional resource use included considering changes in:

- surface and subsurface minerals
- environmentally significant areas (ESAs)
- forestry
- use of local plants for food or spiritual and medicinal purposes
- hunting
- trapping
- fishing
- non-consumptive recreational use

Impact Assessment of the Project

The Project, in combination with other developments in the LSA or RSA, will not cause significant long-term impacts to surface or mineral materials. Timber resources will be adequately salvaged and forest capability will be equivalent to, or greater than, predisturbance levels. Non-consumptive resource use will be reduced during construction and operations. Hunting and trapping potential will be reduced during construction and operations as a result of access restrictions and habitat disruption. Sports fish species will not be affected by the construction and operation of the Project.

Overall impacts to the non-traditional land uses in the area will be affected during the construction and operational phases of the Project. However, reclamation and closure plans will mitigate the adverse impacts and, in some cases, improve the land use capability.

Mitigation

Long-term mitigation measures to reduce impacts to traditional land use include designing a closure plan that accommodates traditional land uses. Shell will consult with local aboriginal communities in preparing a final mine closure plan that will optimize landscape productivity and ensure ongoing capability to support traditional land use practices.

Shell has initiated a process to compensate registered trapline owners.

More general effects will be managed by:

- limiting vegetation cover removal, where possible; and
- staging activities to provide a transition period for both resources and traditional users.

Strategies to minimize impacts to non-traditional resource use include:

- salvaging surface materials, such as gravel, during site clearing;
- minimizing site clearing;
- revegetating to improve protective cover and browse for wildlife species;
- reclamation to return forestry potential to equivalent or greater capability;
- developing timber salvage and end land use plans, in consultation with government agencies and Forest Management Agreement quota holders;
- reforesting using forest species proven to revegetate successfully;
- salvaging all merchantable timber during site clearing;
- including berry producing shrubs in reclamation plans; and
- avoiding altering the Athabasca and Muskeg rivers.

Monitoring

Resource uses in the Project area will be monitored by:

- monitoring for plant species and community type re-establishment;
- establishing plots to examine species composition, community structure, forest growth and shrub productivity; and
- establishing water quality monitoring programs to minimize or eliminate adverse impacts to fish habitat and thus, fishing capability.

Cumulative Effects Assessment

Timber resources will be adequately salvaged and forest capability will be equivalent to, or greater than predevelopment levels. Non-consumptive resource use will be reduced during construction and operations. Hunting and trapping potential will be reduced during construction and operations as a result of access restrictions and habitat disruption. Some fishing opportunities will be lost due to development.

Some ESAs may be affected by changes in terrain, vegetation and wildlife or changes in access. Provided that known ESAs are avoided to the extent possible, and that appropriate mitigation measures are used to further minimize impacts, the cumulative impacts associated with the various developments on ESAs will be minor.

A small proportion of recreational areas is expected to be lost due to the cumulative effects of various developments. Loss will result primarily from changes in access

and changes in terrain, vegetation and wildlife. However, potential recreational sites in the RSA are numerous.

Regional Development Review

The same impacts and conclusions for the CEA scenario are applicable to the RDR scenario.

HISTORICAL RESOURCES

Scope of Assessment

The assessment of the effect of the Project on historical resources included considering the:

- changes in identified historical resource sites
- exposure of additional historical resources sites

Impact Assessment of the Project

The historical resources within the LSA will not be significantly impacted by the Project. The positive effects of the mitigation program will effectively compensate for the residual effects of the Project.

Mitigation

Mitigation strategies involve plans to limit land surface disturbances and archaeological studies to locate, recover and preserve significant resources and information that would otherwise be lost during construction.

Mitigation strategies implemented will be based on the significance of the resources to be affected, will take place in direct impact zones and focus on information recovery. Activities include:

- completing information recovery requirements previously established by Alberta Community Development;
- completing similar requirements for significant resources identified in the impact analysis;
- recovering sample information from sites representative of typical prehistoric land use patterns identified within the LSA;

- examining areas recently cleared of forest to identify significant and atypical resources not previously recognized;
- conducting sample recoveries from these sites before overburden is removed;
- recovering significant palaeoenvironmental information exposed in muskeg and overburden removal; and
- analyzing and interpreting information recovered in a cohesive study that makes a substantive contribution to regional history and prehistory.

Cumulative Effects Assessment and Regional Development Review

Most historical resources in the region have been, and are being identified in association with activities completed as part of activities to support development applications. Therefore, cumulative effects assessments and regional development review for historical resources are completed as part of the specific development impact assessments.

Mitigation Measures and Residual Impacts for Biophysical and Historical Resources

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
AIR QUALITY ISSUES		
AQ-1 Will Muskeg River Mine Project Emissions Result in Exceedances of Ambient Air Quality Guidelines? AQ-2 Will Muskeg River Mine Project Emissions Result in Human Health Effects? AQ-3 Will Muskeg River Mine Project Emissions Result in the Deposition of Acid Forming Compounds That Exceed Target Loadings? AQ-4 Will Muskeg River Mine Project Emissions Result in the Formation of Ozone That Exceeds Air Quality Guidelines?	**Mitigation:** Fugitive PM Emissions: • Mitigation measures to reduce visible and other emissions associated with vegetation clearing will include: timber salvage to reduce required burning; burning when large fuel material has low moisture content; keeping burn piles free of dirt to minimize smoldering; and immediate cleanup of piles following the burn. Areas to be cleared will be minimized. • Mitigation to reduce particulate emissions associated with overburden removal include the selection of mine areas covered with shallow overburden. Shallow depths of overburden reduce fuel use and emissions from haul trucks. Overburden disposal areas will be revegetated to stabilize surfaces. • Roadways will be watered as required during warm, dry conditions to reduce particulate emissions. Water will not be used during winter for safety reasons. Occasionally, other dust suppression methods will be used on the roads. • The exterior surfaces of tailings settling ponds will be revegetated to stabilize sand surfaces.	**Construction / Operation:** • Fugitive PM emissions will result from vegetation clearing, overburden removal, road construction and use, mining activities and tailings management. The residual impacts will be **Negative** in direction, Low (overburden removal and mining activities) to Moderate (vegetation clearing, roads and tailings management) in magnitude, Long-Term in duration, Local in geographic extent (except for vegetation burning, which can be Regional) and Reversible. The degree of concern is **Low** to **Moderate**. • See Human Health Section E12 for analysis of human health effects. **Closure:** • No residual impacts are expected, therefore the degree of concern is Negligible.

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
Continuation of: **AQ-1** Will Muskeg River Mine Project Emissions Result in Exceedances of Ambient Air Quality Guidelines? **AQ-2** Will Muskeg River Mine Project Emissions Result in Human Health Effects? **AQ-3** Will Muskeg River Mine Project Emissions Result in the Deposition of Acid Forming Compounds That Exceed Target Loadings? **AQ-4** Will Muskeg River Mine Project Emissions Result in the Formation of Ozone That Exceeds Air Quality Guidelines?	NO_X Emissions: • Low NO_X burners will be installed on the stationary combustion sources at the plant site to reduce NO_X emissions. • Mine fleet vehicles with emission control technology will be selected to manage NO_X, VOC and PM emissions. VOC Emissions: • Tailings solvent recovery (TSR) will reduce solvent loss to the pond and hence fugitive VOC emissions from the tailings settling pond. • Vapour control will reduce emission from the solvent and product storage tanks. **Monitoring:** • Periodic stack surveys for key sources to confirm NO_X emissions. • Ambient monitoring to confirm NO_X and PM_{10} in the vicinity of the mine. • Confirm fugitive VOC emissions from the mine and tailings settling pond. • Participate in the Southern Wood Buffalo Air Shed Management Zone for regional air quality and meteorology monitoring.	**Construction / Operation:** • Oxides of nitrogen emissions will result from combustion sources that are either stationary (e.g., boilers) or mobile (e.g., mine fleet). The residual impact will be **Negative** in direction, Low to Moderate in magnitude, Long-Term in duration, Local in geographic extent and Reversible. The degree of concern is **Low**. **Closure:** • No residual impacts are expected, therefore the degree of concern is Negligible. **Construction / Operation:** • Hydrocarbon and reduced sulphur emissions will result from volatilization associated with the tailings settling ponds, the extraction plant vents and from fugitive sources, such as exposed oil sands faces. The residual impact will be **Negative** in direction, Moderate (tailings settling pond and oil sands faces) and Low (vents) in magnitude, Long-Term (tailings settling pond and oil sands faces) to intermittent (deaerator vents) in duration, Local in regional extent and Reversible. The degree of concern is **Moderate**. **Closure:** • The presence of fugitive VOC emissions from a dry CT landscape is unknown. However, no residual impacts are expected, therefore the degree of concern is Negligible.
AQ-5 How Will Muskeg River Mine Project Greenhouse Gas Emissions (GHG) Compare to Those Associated With Conventional Production?	**Mitigation:** • The warm water extraction process will result in an energy efficient (low emissions) operation. An efficient mine operation will minimize ore truck haul distances. The selection of a high-grade/low overburden ore body, which minimizes the amount of material handled will minimize energy expenditure and GHG emissions.	**Construction / Operation:** • CO_2 emissions will result from combustion sources that are either stationary (e.g., boilers) or mobile (e.g., mine fleet). **Closure:** • Revegetation and reclamation will result in a carbon sink.

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
	HYDROGEOLOGICAL ISSUES	
GW-1 Will the Muskeg River Mine Project Change Groundwater Levels and Groundwater Flow Patterns?	**Monitoring:** • Groundwater monitoring wells will be installed in surficial aquifers and the Basal Aquifer in selected locations around the perimeter of the mine pit. Groundwater levels in these wells will be monitored periodically, to assess the performance of the overburden dewatering and Basal Aquifer depressurization systems, and to monitor the magnitude of drawdown in the adjacent unmined overburden and Basal Aquifer.	**Construction / Operation / Closure:** • The dewatering of overburden and depressurization of the Basal Aquifer will lower groundwater levels from their natural state. The residual impact will be **Negative** in direction, Low to Moderate in magnitude, Local in geographic extent, Medium to Long-Term in duration and the frequency is High. The degree of concern is **Low**.
GW-2 Will Groundwater Systems Re-establish After Mining and Reclamation?	**Monitoring:** • Monitoring of recovery of groundwater levels will be accomplished by installation of monitoring wells at selected sites within and adjacent to reclaimed mine pits and the reclaimed tailings structure. It will be possible to monitor groundwater levels in the wells periodically over time to establish recovery trends and provide a basis for projecting equilibrium levels.	**Construction / Operation / Closure:** • The groundwater flow systems and groundwater levels that re-establish after mining will be altered from their natural state. However, the groundwater flow patterns will be similar to the natural state. The residual impact will be **Neutral** in direction, Low to Moderate in magnitude, Local in geographic extent, Long-Term in duration and the frequency is High. The degree of concern is **Low**.
GW-3 Will the Muskeg River Mine Project Change Groundwater Quality?	**Mitigation:** • Potential mitigation of seepage impacts may be required if seepage was found to be flowing past the perimeter ditch through surficial aquifers to the Muskeg River. In this event, an appropriate method, such as an interceptor ditch between the river and the tailings settling pond, could be employed to collect tailings seepage before it reaches the Muskeg River. **Monitoring:** Monitoring of groundwater quality during operations and closure will be accomplished by installation of monitoring wells at selected	**Construction / Operation / Closure:** • Groundwater quality in the Basal Aquifer beneath the mine and the tailings settling pond will be altered from the natural state. Groundwater quality in oil sands/lean oil sands and possibly surficial sediments east of CT disposal pits, and on both sides of the tailings settling pond, will also be altered from its natural condition. The residual impact will be **Negative** in direction, Moderate to High in magnitude, Local in geographic extent, Long-Term in duration, Irreversible and of High frequency. The degree of concern is **Low** in the Basal Aquifer, and **Moderate** to **High** in unmined oil sands or surficial aquifers.

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
	sites. Groundwater quality in the wells will be monitored through periodic sampling over time to establish any changes or trends in groundwater quality, and provide a basis for projecting future groundwater quality.	

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
SURFACE WATER ISSUES		
SW-1 Will the Muskeg River Mine Project Affect Flows and Water Levels in Receiving Streams, Lakes, Ponds and Wetlands?	**Mitigation:** • Maximize use of tailings and consolidated tailings porewater release, Basal Aquifer water, and site runoff for process water to minimize raw water withdrawal requirement from the Athabasca River. • Minimize impacts on the flows and water levels in the Muskeg River and Mills Creek by distributing muskeg drainage operations evenly through the mine life to avoid a large increase in flows in the receiving streams. • Minimize impacts of closed-circuit operations on the flows and water levels in Muskeg River and Mills Creek by maximizing diversion of natural runoff from undeveloped areas (no contact with oil sands) around the mining area to the receiving streams. • Minimize impacts on the flows and water levels in the Muskeg River and Mills Creek by developing a drainage layout to minimize the changes in the natural drainage areas of the receiving streams. **Monitoring:** • Monitor flows and water levels at selected sites. • participate in the Regional Hydrology and Climate Monitoring Program, including climate monitoring for correlating with, and interpreting of the results of streamflow monitoring.	**Construction:** • Alsands Drain: The degree of concern of the residual impacts is rated Negligible, although the flow changes in this man-made channel will be relatively High. • Muskeg River: The residual impacts will be **Negative** in direction, Low in magnitude, Local in geographic extent, Medium Term in duration, Reversible and of Intermittent frequency. The degree of concern is **Low**. • Mills Creek: The residual impacts will be **Negative** in direction, Low in magnitude, Local in geographic extent, Medium Term in duration, Reversible and of Continuous frequency. The degree of concern is **Low**. • Isadore's Lake: The changes in inflows to the lake will cause Negligible changes in lake water levels. • Athabasca River: The Project will have Negligible effects on the Athabasca River flows. **Operation:** • Alsands Drain: The degree of concern of the residual impacts is Negligible, although the flow changes in this man-made channel will be relatively High. • Muskeg River: Temporary release of the end pit lake water during the management period may moderately increase the river flows. The residual impacts will be **Negative** in direction, Low to High in magnitude, Local in geographic extent, Medium Term in duration, Reversible and of Continuous frequency. The degree of concern is **Low** to **Moderate**. • Mills Creek: Muskeg drainage and overburden dewatering will temporarily increase the streamflows. The residual impacts will be **Negative** in direction, Low to High in magnitude, Local in geographic extent, Medium Term in duration, Reversible and of Continuous frequency. The degree of concern is **Moderate**. • Isadore's Lake: The changes in inflows to the lake will cause Negligible changes in lake water levels. • Athabasca River: The Project will have Negligible effects on

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
		the Athabasca River flows. **Closure:** • Alsands Drain: The degree of concern of the residual impacts is Negligible, although the flow changes in this man-made channel will be Low to High. • Muskeg River: The residual impacts will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long Term in duration, Irreversible and of Continuous frequency. The degree of concern is **Low**. • Mills Creek: Surface runoff to the creek will be reduced. The residual impacts will be **Negative** in direction, Moderate in magnitude, Local in geographic extent, Long Term in duration, Irreversible and of Continuous frequency. The degree of concern is **Moderate**. • Isadore's Lake: The changes in inflows to the lake will cause Negligible changes in lake water levels. • Athabasca River: The Project will have Negligible effects on the Athabasca River flows.
SW-2 Will the Muskeg River Mine Project Affect Water Balance of Nearby Lakes, Ponds, Wetlands and Streams?	**Monitoring:** • Monitor water levels and outflows at Kearl Lake as part of RAMP.	**Construction / Operation / Closure:** • The degree of concern of the Project residual impacts on the Kearl Lake water balance is Negligible, because the Basal Aquifer depressurization will cause Negligible changes to the lake outflows.
SW-3 Will the Muskeg River Mine Project Affect Basin Sediment Yields and Sediment Concentrations in Receiving Streams?	**Mitigation:** • Minimize incremental sediment loads to the Muskeg River by routing muskeg drainage, overburden dewatering and runoff from site clearing and overburden stripping operations to sedimentation ponds before releasing to the receiving streams. • Follow regulatory guidelines and best management practices to minimize erosion and sediment loading during site clearing and construction of pipeline crossings. • Provide a minimum of 100 m buffer zone between the mining footprint and the	**Construction:** • The degree of concern of the Project residual impacts on the streamflow sediment concentrations in Muskeg River and Mills Creek is Negligible. **Operation:** • Muskeg drainage and overburden dewatering during operation will increase channel erosion in Mills Creek. A temporary large increase of the Muskeg River flows during the end pit lake management period will increase channel erosion in Muskeg River. The residual impacts will be **Negative** in direction, Negligible to Low in magnitude, Local in geographic extent, Medium Term in duration, Reversible and of Continuous frequency.

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
	channels of Muskeg River and Jackpine Creek. • Provide erosion protection measures to minimize erosion of the facilities located in the 100-year flood risk limits. • Construct road ditches to collect and route surface runoff from disturbed areas to polishing ponds before release to receiving streams. • Revegetate areas disturbed during construction by seeding and mulching. • Provide erosion protection measures such as riprap at river crossing embankments. **Monitoring:** • Monitor streamflow sediment concentrations at selected sites.	The degree of concern is **Low**. **Closure:** • The increase of the Muskeg River flows after closure will be small. The residual impacts will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long Term in duration, Irreversible and Continuous. The degree of concern is **Low**.
SW-4 Will the Muskeg River Mine Project Affect Channel Regimes of Receiving Streams?	**Mitigation:** • The measures to minimize increases of flows in receiving streams listed under Key Question SW-1 also help minimize channel erosion potential and thus minimize changes in channel regimes of receiving streams.	**Construction / Operation / Closure:** • Increased streamflows in Muskeg River and Mills Creek will cause small increases in the channel erosion rates. The degree of concern of the Project residual impacts on the channel regimes of Muskeg River and Mills Creek is Negligible.
SW-5 Will the Muskeg River Mine Project Change the Open-Water Areas Including Lakes and Streams?	**Mitigation:** • Create closure reclamation drainage systems consisting of drainage channels, shallow lakes/wetlands and an end pit lake.	**Construction / Operation:** • The Project will displace a small number of shallow lakes/ponds in the Project area. The residual impacts will be **Negative** in direction, Low in magnitude, Local in geographic extent, Medium Term in duration, Reversible and Continuous. The degree of concern is **Low**. **Closure:** • The reclaimed landscape and drainage systems will provide larger open-water areas of streams, wetlands and lakes in the Project area and thus replace the open-water areas lost during construction and operation. The

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
		degree of concern of this impact is Negligible.
SW-6 Will the Muskeg River Mine Project Affect Landscape and Drainage System Sustainability After Closure?	**Mitigation:** • All the reclaimed surfaces will be covered with reclamation material consisting of organic and mineral soils to support vegetation. Sand ridges will be constructed on the sand-capped CT surfaces to provide drained soil conditions to support upland vegetation growth. These measures will minimize surface erosion from the reclaimed landscape. • All the reclaimed surfaces will be built with drainage networks characteristic of natural systems. Drainage networks based on natural systems will ensure minimum gully erosion, which is usually the main source of basin sediment yield from an immature landscape. • All main drainage channels will be built "in regime" by replicating geomorphic relationship exhibited by natural streams. Floodplains will be provided to accommodate extreme flood events including the 100-year and even the Probable Maximum Flood (PMF) without excessive channel erosion and sediment yield. • Shallow lakes, wetlands and the end pit lake will help attenuate flood peak discharges to the downstream channels and minimize flow velocities and channel erosion. Rock breakwaters will be provided to protect the 20% littoral zone to ensure biological productivity and to minimize wave erosion. The large end pit lake will settle sediment runoff from the reclaimed surfaces and minimize risks of increased sediment loading to the Muskeg River.	**Closure:** • A reclamation drainage plan has been designed for the Project to develop a long term reclamation landscape and drainage systems on closure. The residual impacts will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long Term in duration, Irreversible and Continuous. The degree of concern is **Low**.

Key Question/Environmental Issue	Mitigation/Monitoring	Residual Impact
	Monitoring: • A program will be designed for monitoring flows and water quality from the sedimentation ponds.	

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
WATER QUALITY ISSUES		
WQ-1 Will Operational and Reclamation Water Releases From the Project Result in Water Quality Guideline Exceedances in the Athabasca and Muskeg Rivers and Isadore's Lake? **WQ-2** Will Operational and Reclamation Water Releases From the Project Result in Toxicity Guideline Exceedances in the Athabasca and Muskeg Rivers?	**Mitigation:** • Perimeter ditches around the tailings settling pond will penetrate to an underlying low permeability layer. Seepages will be collected and pumped back into the pond during operation; this will effectively prevent seepages from progressing beyond this point. • CT deposited below grade to reduce seepage. • Water from CT will be recycled into the closed-circuit system during operation. • At closure, the perimeter ditch will drain to wetlands before discharging to the Athabasca River. • Wetlands will be developed on CT deposits and reclaimed tailings settling pond. • After operation, sand and CT seepage water will be channeled to the end pit lake for remediation. **Monitoring:** • A water quality monitoring program will be developed in conjunction with RAMP.	**Construction / Operation / Closure:** • Although background levels of several metals exceed water quality guidelines in the Athabasca and Muskeg rivers, no exceedances of water quality guidelines for aquatic life are predicted to occur as a result of the Project. The degree of concern is Negligible. • Exceedances of human health water quality guidelines for two PAH compounds were predicted to occur as a result of end pit lake discharges in the Muskeg River. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Medium-Term in duration, Reversible, and of Medium (several years) frequency. The degree of concern is **Low**. Further evaluation by Human Health Section E12 eliminated these compounds as a concern. • No acute or chronic toxicity guideline exceedances are predicted to occur in the Athabasca and Muskeg rivers. The degree of concern is Negligible. • Isadore's Lake water quality will not be affected.
WQ-3 Will Operational and Reclamation Water Releases From the Project Alter the Temperature Regime of the Muskeg River?	**Mitigation:** • Discontinue filling end pit lake during winter months to control rate of discharge to Muskeg River. • Control end pit lake discharges during critical fish life stages, if necessary. **Monitoring:** • Temperature regime of Muskeg River will be monitored in selected years as part of RAMP.	**Construction / Operation / Closure:** • Adjustment of timing of end pit lake water releases will result in no residual impacts on temperature in the Muskeg River, with the potential exception of reduced diurnal fluctuation. The degree of concern is Negligible for cooling in open water season and slower seasonal temperature changes. It is Undetermined for reduced diurnal fluctuation.
WQ-4 Will Muskeg Dewatering Activities Associated With the Project Reduce Dissolved Oxygen Concentrations to Unacceptable Levels in the Muskeg River?	**Mitigation:** • Sedimentation ponds will be constructed to collect muskeg and overburden (operational) waters.	**Construction / Operation:** • Waters will be controlled and treated if necessary to ensure no residual impacts on dissolved oxygen concentrations. Degree of concern is Negligible.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	• Aerate sedimentation pond, if necessary. **Monitoring:** • The BOD of these waters will be monitored before release.	**Closure:** • Operational waters will no longer be discharged at closure, hence no impact is predicted. The degree of concern is Negligible.
WQ-5 Will PAHs in Operational and Reclamation Waters Released From the Project Accumulate in Sediments and be Transported Downstream?	**Mitigation:** • Sedimentation ponds and wetlands will be constructed to intercept waters and allow settling of particulates. **Monitoring:** • Participation in regional aquatics monitoring program (RAMP).	**Construction / Operation / Closure:** • No accumulation and transport of PAHs in sediments is anticipated, however some uncertainty exists. The residual impact will be **Negative** in direction, Negligible to Low in magnitude, Local in geographic extent, Medium-Term in duration, Reversible and of Moderate frequency. The degree of concern is **Negligible** to **Low**.
WQ-6 Will End Pit Lake Water be Toxic Prior to Discharge to the Muskeg River?	**Mitigation:** • Filling of the end pit lake will be controlled at such a rate that lake discharges will be non-toxic. • 20% littoral zone to enhance biological productivity.	**Construction / Operation / Closure:** • Discharges from end pit lake will not be toxic. The degree of concern is Negligible.
WQ-7 Will Accidental Water Releases Occur That Could Affect Water Quality in the Athabasca and Muskeg Rivers?	**Mitigation:** • Emergency spill response manual. • Spill response training. • Best management practices.	**Construction / Operation / Closure:** • Degree of concern is rated as Negligible.
WQ-8 Will Changes in Water Quality Result From Acidifying Emissions?	**Monitoring:** • Shell will cooperate with other operators in the region to more fully understand acid deposition.	**Construction / Operation / Closure:** • Questions remain about spring runoff impact of acidification on water quality. The residual impact will be **Negative** in direction, Undetermined in magnitude, Local in geographic extent, Medium-Term in duration, Reversible and of Medium frequency. The degree of concern is **Undetermined**.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
AQUATIC RESOURCES ISSUES		
AR-1 Will Muskeg River Mine Project Activities Change Fish Habitat?	**Mitigation:** • Avoid critical sports fish habitat in the Muskeg River or Jackpine Creek. • See design features for minimizing sediment loading (SW-3). • See mitigation to prevent changes in temperature regime of Muskeg River (WQ-3). • Aquatic habitat will be established in the reclaimed landscape including streams, wetlands and an end pit lake. Fish may be introduced into the end pit lake. **Mitigation:** • Habitat monitoring of Isadore's Lake and Muskeg River will be undertaken as part of RAMP.	**Construction / Operation:** • No residual impacts on northern pike, Arctic grayling, longnose sucker, walleye or lake whitefish habitat are anticipated during the life of the Project. The degree of concern is Negligible. • Several small ponds will be lost during construction. The Alsands drainage system, which covers 3.4 ha, will be removed in operation and replaced at closure when it will form the outlet channel from the end pit lake. Habitat of equivalent quality and quantity will be replaced during operation. The residual impact will be **Negative** in direction, Low in magnitude, Medium-Term in duration, Local in geographic extent, Reversible and once in frequency. The degree of concern is **Low**. **Closure:** • **Positive** impact through creation of sport and forage fish habitat in reclaimed landscape (wetlands, streams and end pit lake).
AR-2 Will Muskeg River Mine Project Activities Result in Acute or chronic Effects on Fish?	**Mitigation:** • See mitigation features for WQ-1 and WQ-2.	**Construction / Operation / Closure:** • No residual acute or chronic effects on fish are anticipated. The degree of concern is Negligible.
AR-3 Will Muskeg River Mine Project Activities Change Fish Tissue Quality?	**Mitigation:** • No operational discharges of process-affected water. • See features for WQ-1 and WQ-2. **Monitoring:** • Monitoring of fish tissue for bioaccumulation through RAMP. • Only monitor for tainting if tainting studies indicate potential for tainting from CT water.	**Construction / Operation / Closure:** • No residual acute or chronic effects on fish are anticipated. The degree of concern is Negligible.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
AR-4 Will Muskeg River Mine Project Activities Change Fish Abundance?	**Monitoring:** • Monitoring of fish abundance as part of RAMP.	**Construction / Operation / Closure**: • No residual effects on fish abundance are anticipated. The degree of concern is Negligible.
AR-5 Will Muskeg River Mine Project End Pit Lake Support a Viable Ecosystem?	**Mitigation:** • See design features under WQ-6. • See mitigation under WQ-6. **Monitoring:** • Monitoring of fish health, tainting, bioaccumulation and fish populations. Monitoring plans will be finalized once end pit lake design is final.	**Construction / Operation:** • The end pit lake will start to discharge to the Muskeg River near the end of operation (2029). This rules out effects during these phases. The degree of concern is Negligible. **Closure:** • End pit lake is expected to support a viable aquatic ecosystem, however additional information is required to confirm this; the impact is Undetermined in direction and magnitude.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	ECOLOGICAL LAND CLASSIFICATION ISSUES	
ELC-1 Will the Activities From the Muskeg River Mine Project Result in a Loss or Alteration of ELC Units?	**Monitoring:** • Site clearing for the mine, tailings settling pond, overburden disposal areas, reclamation materials storage areas, roads, plant site, linear infrastructure (e.g., roads and pipelines) and other associated facilities (e.g., ponds and drainage structures) has been designed to minimize area disturbed. • Conduct a reclamation monitoring program to evaluate the re-establishment of ELC units.	**Construction / Operation:** • Some ELC units will be lost or altered due to site clearing and overburden stripping/disposal. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Medium-Term in duration, Reversible and of Low frequency. The degree of concern is **Low to High**. **Closure:** • Vegetation communities will be reclaimed using reclamation materials taken from the Project area. Plantings from intact native vegetation communities as well as supplemental planting with native species will be undertaken. Some ELC units can be reclaimed, while others (e.g., patterned fens) cannot be replaced with current technologies. The residual impact will be **Neutral** in direction, Low in magnitude, Long-Term in duration, Reversible and of Low Frequency. The degree of concern is **Low**.
ELC 2 Will the Activities From the Muskeg River Mine Project Change Biodiversity?	**Monitoring:** • Site clearing for tailings settling pond, overburden disposal sites, muskeg storage areas, end pit lake and linear infrastructure (i.e., roads and pipelines) has been designed to minimize area disturbed. • Reclaim disturbed areas sequentially as development proceeds. • Develop criteria and conduct a program to monitor the change in biodiversity at the landscape level.	**Construction / Operation:** • ELC units will be lost/altered as a result of site clearing and overburden stripping/disposal. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Medium-Term in duration, Reversible and of Low frequency. The degree of concern is **Low to High**. **Closure:** • Vegetation communities will be reclaimed with stored reclamation materials, using native seed mixes and cuttings from intact native vegetation communities. The residual impact will be **Neutral** in direction, Low in magnitude, Long-Term in duration, Reversible and of Low Frequency. The degree of concern is **Low**.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
TERRAIN AND SOILS ISSUES		
TS-1 Will the Activities From the Muskeg River Mine Project Result in Loss or Alteration of Terrain and Soils ?	**Mitigation:** • Conduct phased reclamation over the life of the project. • If direct placement of salvaged reclamation material is not possible it will be stored in temporary reclamation material storage areas. • Naturally developed terrain units and soil cover will be removed during Project development and replaced with recontoured landforms and a reclamation soil mix. **Monitoring**: • Participation in RACQQ Environmental Effects Monitoring for evaluating acidification of sensitive soils from operation emissions.	**Construction / Operation:** • The degree of acidification is Undetermined. • The impact of construction and operations will be **Negative** in direction, High in magnitude, Local in extent, Long-Term in duration and Irreversible. The degree of concern is **Moderate** to **High**.
TS-2 Will Reclamation for the Muskeg River Mine Project Change the Distribution of Terrain and Soils ?	**Mitigation:** • Reconstructed landforms and reclamation materials soil cover will enhance landscape diversity.	**Closure:** • The closure landscape will have greater relief and a wider variety of landforms than the pre-development scenario. The residual impact will be **Positive** in direction. • The reclamation material soil mixes will not be naturally occurring soil types. The residual impact will be **Positive** in direction.
TS-3 Will the Reclamation of the Landscape for the Muskeg River Mine Project Change Soil Productivity ?	**Mitigation:** • Recontoured landforms and reclamation material soil mix will be designed to enhance the potential for forest ecosystem re-establishment.	**Closure:** • There will be more productive soils for forest ecosystems in the reclaimed landscape. The residual impact will be **Positive** in direction.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
TERRESTRIAL VEGETATION ISSUES		
VE-1 Will Muskeg River Mine Project Activities Result in a Loss or Alteration of Vegetation Communities?	**Mitigation:** • Site clearing for the mine, tailings settling pond, overburden disposal sites, reclamation material storage areas, roads, plant site, linear infrastructure (e.g., roads and pipelines) and other associated facilities (e.g., ponds and drainage structures) has been designed to be minimal. • Maintain adjacent areas of native vegetation to use for seed and cutting source during reclamation.	**Construction / Operation:** • Vegetation communities will be lost/altered as a result of site clearing. The greatest impact will occur within the wetland ecosite phases. The residual impact will be **Neutral** to **Negative** in direction, Negligible to Moderate in magnitude, Local in geographical extent, Medium to Long-Term in duration, Reversible and of Low frequency. The degree of concern is **Negligible** to **Low**. • Mine dewatering effects will be limited to the wetlands and lake margins and will not affect terrestrial or upland vegetation communities. The residual impact will be **Neutral** to **Negative** in direction, Negligible to Moderate in magnitude, Local in geographical extent, Medium to Long-Term in duration, Reversible on the east side and Non-Reversible on the west side of the mine footprint and of High frequency. The degree of concern is **Negligible** to **Moderate**.
VE-2 Will Muskeg River Mine Project Air Emissions or Water Releases Alter Vegetation Health?	**Mitigation:** • Direct effects may be minimized by ensuring that ambient concentration levels meet regulatory guidelines. **Monitoring:** • Shell will be a member of the Regional Air Quality Coordinating Committee (RAQCC), which includes an Environmental Effects Monitoring Program.	**Construction / Operation:** • The degree of acidification is Undetermined. • Air emissions associated with Project activities will likely not affect plants negatively. The degree of concern is Undetermined.
VE-3 Will the Muskeg River Mine Project Change Plant Diversity?	**Mitigation:** • Where technically feasible for the final development plan, avoid highly sensitive plant communities and areas with rare plants. • Maintain areas of native vegetation to allow for use during reclamation. These areas will	**Construction / Operation:** • Vegetation communities will be lost/altered as a result of site clearing and overburden stripping/disposal. The greatest impact will occur within the wetlands ecosite phases. The residual impact will be Neutral to **Negative** in direction, Moderate to High in magnitude, Local in

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	provide native sources of seed and vegetation for replanting. • Reclaim disturbed areas sequentially to produce a variety of age classes in the revegetated communities. **Monitoring:** • Component of monitoring program will assess plant species diversity.	geographical extent, Medium to Long-Term in duration, Reversible and of Low frequency. The degree of concern is **Moderate** to **High**.
VE-4 Will Landscape Reclamation and Closure of the Muskeg River Mine Project Result in a Replacement of Plant Communities?	**Mitigation:** • Where technically feasible for the final development plan, avoid highly sensitive plant communities and areas with rare plants. • Maintain adjacent areas of native vegetation to allow for their use during reclamation. These areas will provide native sources of seed and vegetation for replanting. **Monitoring:** • Design a reclamation monitoring program that documents the re-establishment of plant community types.	**Closure:** • Vegetation communities will take time to evolve to pre-development condition. The residual impact will be **Positive** in direction.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	WETLANDS ISSUES	
WL-1 Will Muskeg River Mine Project Activities Result in a Loss or Alteration of Wetlands?	**Mitigation:** • Where technically feasible for the final development plan, avoid highly sensitive wetlands areas (e.g., patterned fens and riparian areas). • Minimize the extent of air emissions through design (e.g., low NO_x burner) and regulatory compliance. **Monitoring:** • Include wetlands vegetation in the local and regional monitoring programs of RAQCC. • Establish a wetlands monitoring site on Lease 13 west to evaluate changes to wetlands due to changes in water levels.	**Construction / Operation:** • Impact to bogs and marshes will be Negligible since they are mostly situated outside the mine development area and most are beyond the aquifer drawdown zone. Some wetlands areas cannot be avoided. The residual impact will be **Negative** in direction, Moderate in magnitude, Local in geographical extent, Long-Term in duration, Irreversible and of Low frequency. The degree of concern is **Moderate**.
WL-2 Will Landscape Reclamation and Closure of the Muskeg River Mine Project Result in a Replacement of Wetlands?	**Mitigation:** • Where technically feasible for the final development plan, avoid highly sensitive wetlands areas (e.g., patterned fens and riparian areas). Maintain areas of native wetlands vegetation to provide donor site for wetlands reclamation. These areas will provide native sources of seed and vegetation for replanting. • Development of wetlands systems in association with reclamation drainage systems, as well as reclaimed CT pits and the tailings settling pond. **Monitoring:** • Participate in the RAMP wetlands vegetation monitoring program to document the re-establishment of plant species and plant	**Closure:** • Wetlands types such as shallow open water and marshes will be reclaimed using native seed and plantings from undisturbed wetlands communities within the Project area. However, other wetland types (e.g., patterned fens) cannot be reclaimed with present technologies. Although some wetlands will be reclaimed, the distribution and composition of wetlands is expected to change over the life of the Project. The residual impact will be **Positive** in direction.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
WETLANDS ISSUES		
	community types. Expand to reclamation wetlands sites over time.	
WL-3 Will the Muskeg River Mine Project Change Wetlands Diversity?	**Mitigation:** • Successive revegetation over the course of mine development will allow for a variety of revegetated wetlands age classes to develop, promoting diversity of wetlands successional stages.	**Closure:** • Wetlands types such as shallow open water and marshes will be reclaimed using native seed and plantings from undisturbed wetlands communities within the Project area. However, other wetlands types (e.g., patterned fens) cannot be reclaimed with present technologies. Although some wetlands will be reclaimed, the distribution and composition of wetlands is expected to change. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, and Long-Term in duration. The degree of concern is **Low**.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	WILDLIFE ISSUES	
W-1 Will Activities From the Muskeg River Mine Project Change Wildlife Habitat?	**Mitigation:** • Locate the development away from important wildlife habitat, where practical. • Phased reclamation of the development area. **Monitoring:** • Assess wildlife use of possible corridors.	**Construction / Operation:** • Wildlife habitat will be lost/altered due to site clearing and other Project activities. The residual impacts will be **Negative** in direction, High in magnitude for most KIRs (e.g., moose habitat units will be reduced by 54% in the LSA). The degree of concern is **Moderate**.
W-2 Will Water Releases From the Muskeg River Mine Project Change Wildlife Health?	**Mitigation / Monitoring:** • Refer to Section E5 for mitigation measures and monitoring for water quality and Section E6 for Aquatic Resources. • Water quality monitoring (component of RAMP).	**Construction / Operation / Closure:** • During operation and closure, no impacts were identified for all chemicals evaluated. However there is uncertainty regarding the potential chronic effects of naphthenic acids on animals. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Medium frequency. The degree of concern is **Low**.
W-3 Will Consumption of Plants Affected by Muskeg River Mine Project Change Wildlife Health?	**Mitigation:** • Refer to Section E2 for mitigation measures for air emissions that may affect the quality of local plants. **Monitoring:** • Participation in the Environmental Effects Monitoring (EEM) Subcommittee of the Regional Air Quality Coordinating Committee for Southern Wood Buffalo Zone to undertake periodic monitoring of plant tissue concentrations and corresponding soil concentrations outside the development area.	**Construction / Operation:** • During operation, no impacts to wildlife health were identified based on consumption of plants in areas outside the development area where wildlife will be foraging. The Degree of Concern is Negligible. **Closure:** • Residual impacts to health foraging of wildlife on the reclaimed landscape following closure are discussed under key question W-7.
W-4 Will the Combined Exposure to Water, Aquatic Invertebrates and Plants Affected by the Muskeg River Mine Project Change Wildlife Health?	**Mitigation:** • Refer to Section E5 for mitigation measures for water quality and Section E2 for mitigation measures for air emissions that	**Construction / Operation / Closure:** • During operation and closure, no impacts were identified for all chemicals evaluated. However, there is some uncertainty regarding the potential chronic effects

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	may affect the quality of local plants. **Monitoring:** The monitoring programs outlined for key questions W-2 and W-3 also apply here.	of naphthenic acids. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Medium frequency. The degree of concern is **Low**.
W-5 Will the Muskeg River Mine Project Change Wildlife Abundance or Diversity?	**Mitigation:** • Implement a nuisance wildlife management plan in cooperation with Fish and Wildlife Service, AEP. • Where feasible, design straight roads with long lines-of-site • Maintain vegetation free shoreline in tailings pond. • Use bird deterrence devices, particularly during the spring and fall migration periods, such as human effigies and propane-fuelled cannons. • Participate in the Oil Sands Bird Protection Committee to discuss mitigation results and strategies. **Monitoring:** • Wildlife-tailings pond mortality. • Wildlife-traffic mortalities.	**Construction / Operation / Closure:** • Changes in wildlife abundance and diversity will result in the LSA primarily due to changes in wildlife habitat. The extent of these changes depends on the amount of habitat lost or altered (Golder 1998b). The residual impact will be **Negative** in direction, High in magnitude, Local in geographic extent, Medium-Term in duration, Reversible and of Low frequency. The degree of concern is **Moderate**.
W-6 Will the Reclaimed Landscape From the Muskeg River Mine Project Change Wildlife Habitat?	**Mitigation:** • Mitigation will be reclamation of the development area to vegetation communities that will support the desired end land uses. **Monitoring:** • Monitoring of wildlife habitat variables on reclaimed lands to closure.	**Closure:** • There will be gains in some wildlife habitats (e.g., upland habitats) and losses in others (e.g., wetlands). Some habitats are more difficult to reclaim than others (e.g., patterned fens). Moose habitat is projected to increase by 10% over baseline, beaver habitat will decrease by 6% and western tanager habitat will increase by 189%. Most impacts will be **Positive** in direction.
W-7 Will the Reclaimed Landscape From the Muskeg River Mine Project Change Wildlife Health?	**Mitigation:** • Refer to Section E16 for mitigation measures considered for closure planning and	**Closure:** • During operation, no impacts to wildlife health were identified based on consumption of plants in areas

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	reclamation of the development site. **Monitoring:** • Periodic monitoring of plant tissue concentrations and soil concentrations on the reclaimed landscape. • Participation of Shell in the Environmental Effects Monitoring (EEM) Subcommittee of the Regional Air Quality Coordinating Committee for Southern Wood Buffalo Zone.	outside the development area where wildlife will be foraging. However, there is a lack of toxicity data respecting naphthenic acids. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Medium frequency. The degree of concern is **Low.**
W-8 Will the Reclaimed Landscape and Post-disturbance Activities From the Muskeg River Mine Project Change Wildlife Abundance or Diversity?	**Monitoring:** • Monitoring of wildlife populations on reclaimed lands to closure.	**Closure:** • There will be a gain in abundance for some wildlife species (e.g., moose, western tanager) and a loss in abundance for other wildlife species (e.g., wetlands species) due to changes in habitat. Most impacts will be **Positive** in direction.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	HUMAN HEALTH ISSUES	
HH-1 Will Water Releases From the Muskeg River Mine Project Change Human Health?	**Mitigation:** • Refer to Section E5 for mitigation measures for water quality. **Monitoring:** • Refer to Section E5 for water quality monitoring and integration with RAMP. In addition, consideration will be given to resolve data gaps in toxicity data for naphthenic acids as part of CONRAD.	**Construction / Operation / Closure:** • During operation and closure no significant health impacts were identified for human health; however, there is some uncertainty regarding the chronic toxicity of naphthenic acids. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Medium frequency. The degree of concern is **Low**.
HH-2 Will Air Emissions From the Muskeg River Mine Project Change Human Health?	**Mitigation:** • Refer to Section E2 for mitigation measures for air quality. **Monitoring:** • Refer to Section E2 for air quality monitoring.	**Construction / Operation:** • During construction and operation, no significant health impacts were identified as a result of air emissions. Therefore, the degree of concern was Negligible. **Closure:** • No particulate or volatile air emissions are anticipated following closure.
HH-3 Will Consumption of Local Plants and Game Animals Affected by the Muskeg River Mine Project Change Human Health?	**Mitigation:** • Refer to Section E2 for mitigation measures for air quality which may also mitigate deposition of air contaminants on plant and soils that ultimately may be consumed by humans. **Monitoring:** • Periodic monitoring of plant and animal tissue from local and regional locations to better characterize spatial and temporal trends, and to improve exposure analysis, should be conducted on a regional basis.	**Construction / Operation / Closure:** • During operation and closure no significant impacts were identified for human health as a result of consumption of native plants or wild game; therefore the concern is Negligible.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
HH-4 Will the Combined Exposure to Water, Air, Plants and Game Animals Affected by the Muskeg River Mine Project Change Human Health?	**Mitigation:** • Refer to Section E5 for mitigation measures for water quality. **Monitoring:** • Refer to Section E5 for water quality monitoring and integration with RAMP. In addition, consideration should be given to resolve data gaps in toxicity data for naphthenic acids as part of CONRAD.	**Construction / Operation / Closure:** • During operation and closure no significant impacts were identified for human health through this multimedia exposure pathway. However, there is some uncertainty regarding the chronic toxicity of naphthenic acids. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Medium frequency. The degree of concern is **Low**.
HH-5 Are Sufficient Procedures in Place to Assure Worker Health and Safety During Construction and Operation of the Muskeg River Mine Project? *(operation phase)*	**Mitigation:** • Corporate training programs in place to enhance worker knowledge of safe and emergency response training and procedures.	**Construction / Operation / Closure:** • Qualitative evaluation of the corporate policies and procedures respecting worker health and safety indicated the necessary resources and know-how were in place to ensure worker health and safety and emergency response planning. The impact is Negligible.
HH-6 Will noise from Muskeg River Mine Project Activities during Construction and Operation Unduly Affect People who Reside in the Local Area?	**Mitigation:** • Manage the location of equipment based on monitoring results. Possible sound attenuating barriers if needed. **Monitoring:** • Ambient noise monitoring with multiple octaves, at various nodes.	**Construction / Operation:** • Truck and shovel operation may cause periodic exceedances of permissible sound level in Fort McKay. This may arise from unique additive circumstances of the Project plus the Aurora Mine. The residual impact will be **Negative** in direction, Low in magnitude, local in geographic extent, Long-Term in duration, Reversible and of Medium Frequency. The degree of concern is **Low**. **Closure:** • Work related noise will cease at closure.
HH-7 Will the Release of Chemicals From the Reclaimed Landscape Change Human Health?	**Mitigation:** • Refer to Section E5 for mitigation measures for water quality. **Monitoring:** • Refer to Section E5 for water quality monitoring and integration with RAMP.	**Closure:** • Following closure in the far future when equilibrium conditions have been established, the multimedia exposure risk assessment indicated no significant impacts to human health through this multimedia exposure pathway. However, there is some uncertainty regarding the chronic toxicity of naphthenic acids. The

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
		residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Low frequency. The degree of concern is **Low**.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	HISTORICAL RESOURCES ISSUES	
HR-1 Will Development Activities Associated With the Muskeg River Mine Project Change Sites, Warranting Avoidance or Further Information Recovery? **HR-2** Will the Mitigation Program Designed for Muskeg River Mine Project Effectively Offset Project Effects?	**Mitigation:** • Avoidance: No historical resources identified within the development area require permanent avoidance. • Pre-development mitigation: completion of existing mitigation requirements previously established by Alberta Community • Pre-development mitigation for significant sites within impact zones, including the Bezya site (HhOv 73) as required by Alberta Community Development. • Completion of mitigation requirements set by Alberta Community Development for sites of Moderate value situated in impact zones. Studies would focus on sites that represent unusual sources of information and on representative sampling from typical sites. **Monitoring:** • Surface inspection of recently cleared areas to record exposed sites. Sample recovery from unique sites or representative sites if no comparable samples exist for the area in question. • Palaeoenvironmental sampling: recovery of bone and other relevant materials exposed during muskeg removal.	**Construction / Operation:** • During construction and operation stages, sites within impact zones will be completely removed. Residual impacts will occur in the form of destruction of those historical resources not recovered during mitigation programming. Samples recovered for permanent preservation, along with their analysis and interpretation, will adequately offset these effects. Because low value resources would be affected, residual impacts will be **Negative** in direction, Low in magnitude, Localized to development zones, Short-Term in duration and Irreversible. Degree of concern is **acceptable**.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
	RESOURCE USE ISSUES	
RU-1 Will There be a Change in Surface and Mineral Materials ?	**Mitigation:** • Salvage materials (e.g., gravel) during site clearing, where possible.	**Construction / Operation:** • During construction and operation, restricted access will reduce potential for other extraction purposes. The residual impact will be **Negative** in direction, of Moderate magnitude, of Local geographic extent, Medium-Term duration and Reversible. The degree of concern is **Low**. **Closure:** • Following closure, surface and other mineral extraction may occur and may be enhanced due to improved access.
RU-2 Will There be a Change in Environmentally Significant Areas (ESAs) ?	**Mitigation:** • Minimize clearing as much as possible. Re-vegetation will enhance cover for wildlife. • Reclaim areas to the extent possible with by reseeding and planting with native vegetation.	**Construction / Operation:** • Minor changes to Kearl Lake moose habitat. The degree of concern is Negligible.
RU-3 Will There be a Change in Forestry ?	**Mitigation:** • Salvage merchantable timber during site clearing. Keep site clearing to the smallest possible area. • Develop a forest management plan in conjunction with the FMA quota holder and the government for closure planning. Reclaim forest to equivalent or greater capability. **Monitoring:** • A monitoring program will be designed to document the establishment of regeneration for commercial forestry purposes.	**Construction / Operation:** • Site clearing will remove productive forest and regeneration during the life of the Project. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Long-Term in duration, Reversible and of Low frequency. The degree of concern is **Low**. **Closure:** • The forest resource will be reclaimed to equivalent or greater capability. As well, access should be enhanced following closure. Thus, impact on forestry is expected to be **Positive** in the long term.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
RESOURCE USE ISSUES		
RU-4 Will There be a Change in Berry Picking ?	**Mitigation:** • Revegetation schemes should include berry-producing shrubs where possible.	**Construction / Operation:** • Loss of vegetation due to site clearing and restricted access will affect berry picking activities. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Moderate in duration, Reversible and of Low frequency. The degree of concern is **Low**. **Closure:** • Opportunities for berry picking are expected to increase due to careful reclamation and improved access.
RU-5 Will There be a Change in Non-consumptive Recreational Use ?	**Mitigation:** • Leave buffers of native vegetation between disturbance and watercourses and highways to reduce visual impact.	**Construction / Operation:** • Loss of vegetation due to site clearing and restricted access will affect recreational activities. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Moderate in duration, Reversible and of High frequency. The degree of concern is **Low**. **Closure:** • Opportunities for recreation are expected to increase due to careful reclamation and improved access.
RU-6 Will There be a Change in Hunting ?	**Mitigation:** • Reclaim site to equivalent or greater capability for wildlife.	**Construction / Operation:** • Loss of wildlife due to construction and operations and restricted access will affect hunting opportunities. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Moderate in duration, Reversible and of Moderate frequency. The degree of concern is **Low**. **Closure:** • Opportunities for hunting are expected to increase due to careful reclamation and improved access. The impact is **Positive**.

Key Question/Environmental Issue	Design Feature/Mitigation/Monitoring	Residual Impact
RESOURCE USE ISSUES		
RU-7 Will There be a Change in Trapping ?	**Mitigation:** • Reclaim site to equivalent or greater capability for wildlife. Reimburse trappers for lost revenue.	**Construction / Operation:** • Loss of wildlife due to construction and operations and restricted access will affect trapping opportunities. The residual impact will be **Negative** in direction, Low in magnitude, Local in geographic extent, Moderate in duration, Reversible and of Moderate frequency. The degree of concern is **Low**. **Closure:** • Opportunities for trapping are expected to increase due to careful reclamation and improved access. The impact is **Positive**.
RU-8 Will There be a Change in Fishing ?	**Monitoring:** • Monitor water quality to ensure that fish abundance and health are not affected.	**Construction / Operation:** • No changes will occur to sport fishing as a result of the Project. **Closure:** • Opportunities for fishing may increase due to improved access and the creation of the end pit lake.

Table A-3 Mitigation Measures and Residual Impacts for Socio-Economics

Key Question/Socio-Economic Issue	Mitigation/Monitoring	Residual Impact
SOCIO-ECONOMIC ISSUES		
What is the impact on local employment and training?	• Local hiring, but always on merit. Shell will use and encourage local businesses - including First nations and Metis businesses - where they are competitive and can meet Shell's requirements. **Mitigation:** • Provide local educational institutions with population forecast to aid planning. • Participate in career days and similar events, consideration given to aboriginal scholarship fund.	• Enhanced local employment and business opportunities.
What are the impacts on local services and infrastructure?	**Mitigation:** • Active cooperation with the municipality and other levels of government to identify impacts and explore solutions. The Athabasca Oil Sands Facilitation Committee and the Regional Infrastructure Working Group on Training and Education are examples of collaborative initiatives. • Use of construction camp, that may be kept open partially during operations phase. • Participation in the Career Preparation and other education programs; Employee orientation programs and EAP. • Development of corporate charitable donation policy; encouragement of volunteer efforts of staff. • Provision of basic medical services to workers on site; disaster planning. • Mutual aid agreements with other emergency services.	• Temporary housing shortage; remaining concern about the availability of rental accommodations. • Increased demand on social and emergency service providers. • Increased traffic on Highway 63, especially north of the urban service area.

Key Question/Socio-Economic Issue	Mitigation/Monitoring	Residual Impact
	• Traffic scheduling to avoid peak hours; bussing services for commuting workers.	
What are the impacts on the procurement of local, Alberta and Canadian goods?	**Mitigation:** • Procurement of local, Albertan and Canadian goods and services, where competitive and able to meet the project needs.	• Increased opportunity for local, Albertan and Canadian suppliers.

Summary of Residual Impacts for CEA and RDR

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
	AIR QUALITY ISSUES	
AQCEA-1Will emissions from combined developments result in exceedances of ambient air quality guideline?	• The dispersion model predictions indicate that hourly and daily NO_2 concentrations should be less than the air quality guidelines. The annual average NO_2 concentrations, however, may exceed the guideline adjacent to the respective mines.	• The conclusions for the RDR are the same as for the CEA.
AQCEA-2 Will emissions from combined developments result in human health effects?	• The impact classification associated with these extrapolated concentration estimates is presented in the human health CEA.	• The impact classification associated with these extrapolated concentration estimates is presented in the human health section.
AQCEA-3 Will emissions from combined developments result in deposition of acid forming compounds that exceed target loadings?	• While the SO_2 emissions in the RSA are expected to be relatively stable (or perhaps even decrease), the RSA NO_X emissions are predicted to increase by about 40% over baseline levels. Of the increase from 78 to 110 t/d, the Muskeg River Mine Project accounts for 12 t/d. • The area where the PAI exceeds the 0.25 keq/ha/a target loading for sensitive ecosystem increases from 1,500 km^2 for the baseline emissions to 1800 km^2 with the addition of the project emissions. Under the CEA emissions scenario, the area further increases to 2,500 km^2.	• The RSA NO_X emissions are predicted to increase by about 150% over baseline levels. Of the increase from 78 to 195 t/d, the Muskeg River Mine Project accounts for 12 t/d. • The area where the PAI exceeds the 0.25 keq/ha/a target loading for sensitive ecosystem increases from 2,500 km^2 for the CEA emissions to 4,200 km^2 for the RDR emissions.
AQCEA-4 Will precursor emissions from combined developments result in the formation of ozone (O_3) concentrations that exceed air quality guidelines?	• Precursor NO_X and VOC emissions are estimated to increase by about 40 and 15%, respectively. The level of confidence for the VOC estimates, however, are lower than that for the NO_X emission estimates. • The estimated CEA NO_X emissions of 110 t/d are similar to those from urban areas such as Calgary (115 t/d) and Edmonton (151 t/d). The CEA VOC emissions of 50 t/d are less than one-half those from Calgary (120 t/d) and Edmonton (140 t/d). Photochemical modelling for these cities indicates a potential for downwind ozone values to exceed the guideline value of 82 ppb. • The previous application of the smog model to the RSA indicates a potential for the guideline value to be exceeded.	• precursor NO_X and VOC emissions are estimated to increase by about 150 and 30%, respectively. • There is a potential for downwind ozone values to exceed the guideline value of 82 ppb. • Shell will participate in an industry indicated study (with Syncrude and Suncor) to undertake more refined photochemical modelling using the recent VOC data and a more up-to-date photochemical model.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
	• Shell will participate in an industry initiated study (with Syncrude and Suncor) to undertake more refined photochemical modelling using more recent VOC data and more up-to-date photochemical model.	
HYDROGEOLOGICAL ISSUES		
GWCEA-1: Will Combined Developments Result in a Drawdown of Water Levels in the Basal Aquifer and Cause a Loss of Water From Important Lakes?	• The impact is expected to be limited to Kearl Lake. • The cumulative impacts on Kearl Lake from drawdown, due to depressurization of the Basal Aquifer, are such that downward seepage from the lake will increase over both natural rates and the rate associated only with the Muskeg River Mine Project. This impact is not expected to extend to McClelland Lake. The complete recovery of groundwater levels in the Basal Aquifer is likely to take up to 30 years after completion of mining, however, groundwater levels will eventually recover.	• Any additional production of groundwater from the Basal Aquifer due to other proposed developments will not have any additional effect on the downward seepage from Kearl Lake, since the analysis in the CEA already represents the upper limit for vertical seepage. • In the presence of other regional developments such as the Mobil Kearl Mine and SOLV-EX developments, the maximum downward seepage from Kearl Lake would be the same as the combined effect of the Muskeg River Mine and Aurora developments. That is, downward seepage from Kearl Lake would increase to 63 mm/year from 24 mm/year representing natural (pre-mining) conditions. Seepage of 63 mm/year represents about 14% of the mean annual precipitation received by the lake.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
	SURFACE WATER ISSUES	
SWCEA-1: Will combined developments in the Muskeg River basin result in effects on the Muskeg River flows, sediment concentrations and channel regime?	• During construction and operation phases of the oil sands developments, the combined developments will cause small to large increases (4% to 23%) in the Muskeg River flows, primarily as a result of muskeg drainage, overburden dewatering, and transfer of the MFT to the end pit lake during reclamation of the Muskeg River Mine Project. • In far future, the average river flows in Muskeg River will increase slightly because the reclaimed surfaces will have different runoff characteristics from the natural basins. • During construction and operation phases of the oil sands developments, the increased Muskeg River flows will cause an increase in the streamflow sediment concentration by 0.2 to 1.2 mg/L and will cause a negligible increase in the channel erosion rate. • In the far future, the small increase in the Muskeg River flows will cause negligible changes in the river streamflow sediment concentration and channel regime.	• During construction and operation phases of the oil sands developments, the combined developments will cause small to large increases (4% to 23%) in the Muskeg River flows, primarily as a result of muskeg drainage, overburden dewatering, and a transfer of the MFT to the end pit lakes during mine reclamation. • In far future, the average river flows in Muskeg River will be similar to the natural conditions • During construction and operation phases of the oil sands developments, the increased Muskeg River flows will cause an increase in the streamflow sediment concentration by 0.2 to 1.2 mg/L and will cause a negligible increase in the channel erosion rate. • In the far future, there will be negligible changes in the river streamflow sediment concentration and channel regime.
SWCEA-2: Will combined developments result in effects on Athabasca River flows?	• During construction and operation phases of the oil sands developments, the regional developments will cause negligible changes to the mean flow conditions on Athabasca River. • After closure of all the oil sands developments, the regional developments will cause negligible changes to the mean flow conditions on Athabasca River.	• During construction and operation phases of the oil sands developments, the combined developments will cause small changes to the mean flow conditions on Athabasca River. • As determined in the CEA, after closure of all the oil sands projects, the developments will cause negligible changes to the mean flow conditions on Athabasca River.
SWCEA-3: Will combined developments result in effects to the open-water areas including lakes and streams?	• During construction and operation phases of the oil sands developments, the developments will permanently remove 464 ha of the natural open-water areas at the development areas. • After closure of all the oil sands developments, closure drainage systems at the reclaimed development areas will create 5,664 ha of new open-water areas.	• During construction and operation phases of the oil sands developments, the developments will permanently remove 852 ha of the natural open-water areas. • After closure of all the oil sands developments, closure drainage systems at the reclaimed mine sites will create 8,534 ha of new open-water areas which will replace the existing open-water areas lost to mine development.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
	WATER QUALITY ISSUES	
WQCEA-1: Will Operational and Reclamation Water Releases From Combined Developments Result in Water Quality Guideline Exceedances in the Athabasca and Muskeg Rivers?	• The combined developments considered in the CEA will cause exceedances of water quality guidelines for a number of metals, in addition to natural exceedances by certain metals. Although, exceedances of human health water quality guidelines were predicted to occur for two PAH compounds during initial high EPL discharges and in the Far Future, follow-up risk analysis in Section F11 and Section F12 did not identify these compounds as a concern to wildlife and human health.	• Concentrations of most substances exceeding guidelines in the RDR are identical to, or slightly higher than predicted concentrations in the CEA.
WQCEA-2: Will Operational and Reclamation Water Releases From Combined Developments Result in Toxicity Guideline Exceedances in the Athabasca and Muskeg Rivers?	• No exceedances of toxicity guidelines were predicted.	• No exceedances of toxicity guidelines were predicted
WQCEA-3: Will Operational and Reclamation Water Releases From Combined Developments Alter the Temperature Regime of the Muskeg River?	• Temperature fluctuations in the Muskeg River, as a result of changing flow regimes, will remain within temperature guidelines. However, uncertainties remain regarding potential effects on seasonal warming and cooling of river water and changes in diurnal temperature fluctuation. • Greater temperature declines were predicted during the open-water season in the CEA than in the Impact Assessment and the potential for slower seasonal warming and cooling is greater than predicted in the Impact Assessment.	• Compared to impact predictions in the CEA, temperature declines predicted in the RDR are slightly larger, but within temperature guidelines.
WQCEA-4: Will Muskeg and Overburden Dewatering Activities From Combined Developments Reduce Dissolved Oxygen Concentrations to Unacceptable Levels in the Muskeg River?	• Dissolved oxygen impacts from muskeg drainage waters are not anticipated to occur.	• No further concern is evident compared to the CEA.
WQCEA-5: Will PAHs in Operational and Reclamation Water Releases From Combined Developments Accumulate in Sediments and Be Transported Downstream?	• PAH accumulation in sediments is not anticipated to occur due to limited available pathways, although uncertainties remain regarding release rates of PAHs from oil sands developments.	• Although impacts on sediment PAH levels are unlikely, this issue remains a potential concern related to oil sands developments. Due to the qualitative nature of the analysis, it is not possible to estimate differences in sediment PAH levels between the RDR, CEA and those identified in the impact assessment in the CEA in Section F5.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
WQCEA-6: Will Acidifying Emissions From Combined Developments Result in Changes in Water Quality?	• Acidification of waterbodies due to air emissions cannot be evaluated with a high degree of certainty at this time due to limited data on sensitivity of surface waters in the RSA to acidification. Although year-round acidification of surface waters in the RSA is highly unlikely, available data suggest that spring pH depression in sensitive waterbodies is a potential impact that should be examined further. • The predicted size of the area affected by deposition of acidifying substances, based on air quality modelling, will be 39% larger in the CEA than in the Impact Assessment. The Project is accountable for approximatley 36% of this increase.	• Compared to impact predictions in the CEA, the size of the potentially affected area identified, as predicted by air quality modelling for the RDR, increases by 68%. The Project is accountable for less than 1% of this increase.
AQUATIC RESOURCES ISSUES		
ARCEA-1: Will activities from the combined developments change fish habitat?	• No impacts on northern pike or Arctic grayling habitat are predicted. • No negative effects are predicted for longnose sucker habitat. • For the CEA, loss of forage fish habitat (1.7%) is predicted in the RSA. The Project contributes less than 0.1% of this impact. At each stage in the developments, habitat disturbed will be replaced with habitat of equivalent or better productivity. Forage fish habitat replaced through reclamation will result in a net gain (20% more that currently exists) in habitat for both forage fish and sport fish in the Far Future.	• No impacts on northern pike of Arctic grayling habitat are predicted. • No negative effects are predicted for longnose sucker habitat. • For the RDR, loss of forage fish habitat (3.1%) is predicted in the RSA. This loss elevated over the CEA where the loss is about 1.7%. The Project contributes less than 0.1% of this impact. At each stage in the developments, habitat disturbed will be replaced with habitat of equivalent or better productivity. Forage fish habitat replaced through reclamation will result in a net gain (30% more that currently exists) in habitat for both forage fish and sport fish in the Far Future.
ARCEA-2: Will operational and reclamation water releases from combined developments result in acute or chronic effects on fish?	• No acute or chronic effects on fish as a result of changes in temperature, dissolved oxygen, sediment or water quality are predicted.	• No acute or chronic effects on fish as a result of changes in temperature, dissolved oxygen, sediment or water quality were predicted.
ARCEA-3: Will operational and reclamation water releases from combined developments result in changes to fish tissue quality?	• No tainting or accumulation of chemicals in fish are predicted.	• No tainting or accumulation of chemicals in fish are predicted.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
ARCEA-4: Will operational and reclamation water releases from combined developments result in changes in fish abundance?	• No changes in fish abundance are expected as a result of acute and chronic effects, change in access or habitat.	• No changes in fish abundance are expected as a result of acute and chronic effects, change in access or habitat.
ECOLOGICAL LAND CLASSIFICATION ISSUES		
ELCCEA-1: Will activities from combined developments result in a loss or alteration of ELC units and diversity?	• In this CEA, the total losses to macroterrain units are 22,598 ha or 2.1% of the RSA. The Project will contribute 4,343 ha or 0.4% of the loss in the RSA.	• The combined developments will remove 40,633 ha or 3.9% of macroterrain units in the RSA. The Project will contribute less than 0.1% to this reduction. The total number of macroterrain units will not decrease and therefore, the diversity will not change.
TERRAIN AND SOILS ISSUES		
TSCEA-1: Will combined developments alter the quantity and distribution of terrain and soil units?	• During construction and operations phases the combined developments will cause a loss of 2.1% of the natural terrain and soil units in the RSA. The phased nature of development and reclamation will mediate the concern. • Reclamation of the developed areas with reconfigured terrain units covered by a reclamation soil mixture will produce very Positive impacts by increasing the diversity of terrain units.	• During the construction and operation phases of the combined developments will cause a loss of 3.9% of the natural terrain and soil units in the RSA. • This is a worst case perspective as it is unlikely that all sites will be developed to their maximum extent concurrently. The phased nature of development and reclamation will mediate the degree of concern. • Reclamation of the developed areas and existing disturbed areas with reconfigured terrain units covered by a reclamation soil mixture will produce very Positive impacts by increasing the diversity of terrain units.
TSCEA-2: Will combined developments alter soil capability and sensitivity?	• As a result of alterations in the quantity and distribution of soil and terrain units between the pre-development and closure landscapes, changes in soil capability will be produced. These are estimated to be: Positive in direction. The positive direction of change is the result of significant areas of non-productive class 4 and 5 land being reclaimed to low and moderately productive classes 2 and 3. • Operational activities of the developments will increase the levels of potentially acidifying emissions released into the RSA air shed. Associated with this is a low level of certainty as the PAI-soil acidification linkage is ill-defined.	• As a result of alterations in the quantity and distribution of soil and terrain units between the pre-development and closure landscapes, changes in soil capability will be produced. The Positive direction of change is the result of significant areas of non-productive class 4 and 5 land being reclaimed to low and moderately productive classes 2 and 3. • Operational activities of the developments will increase the levels of potentially acidifying emissions released into the RSA air shed.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
TERRESTRIAL VEGETATION ISSUES		
TVCEA-1: Will the combined developments, their reclamation and closure, result in a loss or alteration of vegetation communities?	• Loss of vegetation communities (28,642 ha or 2.8%) is predicted in the RSA. The Project contributes 4,343 or 0.4% of this impact. • All disturbed areas will be revegetated in accordance with reclamation plans. There will be a small increase in upland communities.	• Loss of vegetation communities (34,163 ha or 3.2%) is predicted in the RSA. The Project contributes 807 or 0.1% of this impact. • The RDR reclamation will increase terrestrial vegetation by 6.4% to 312,011 ha or 29.7% of the RSA.
TVCEA-2: Will the combined developments result in a change in vegetation diversity?	• There may be a short-term reduction in diversity within the RSA.	• There may be a short-term reduction in diversity within the RSA.
TVCEA-3: Will air emissions from combined developments result in a change to vegetation health?	• Vegetation health is not expected to be affected.	• Vegetation health is not expected to be affected.
WETLANDS ISSUES		
WTCEA-1: Will combined developments, their reclamation and closure, result in a loss or alteration of wetlands?	• The total loss of wetlands from the combined developments is 54,834 ha or 5.2% of the RSA. The Project's contribution to this loss is 6.1% under the CEA.	• The total loss of wetlands from the combined developments is 67,126 ha or 6.4% of the RSA. The Project's contribution to this loss is 5.0% under the RDR.
WTCEA-2: Will reclamation and closure of combined developments result in replacement of wetlands?	• Reclamation activities and reforestation will result changes to the distribution of wetland types in the RSA. Overall, fens and bogs will be reduced by 1.5% but marshes will increase by 0.3 % in the RSA.	• Overall, fens and bogs will be reduced by 2.6%, but marshes will increase by 0.1% in the RSA.
WILDLIFE ISSUES		
WCEA-1: Will the combined developments impact wildlife habitat?	• During the construction and operation phases of the oil sands developments, the combined developments will cause relatively small (1.2 - 3.1% of the RSA) losses of wildlife habitat due to site clearing and disturbance. The phased nature of site clearing and progressive reclamation will mitigate the cumulative effects of habitat loss. • Eventual reclamation of all sites should result in equivalent habitat capability for wildlife within the region.	• During the construction phase of the oil sands developments, the combined developments will cause relatively small (3.2 - 6.2% of the RSA) losses of wildlife habitat due to site clearing and disturbance.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
WCEA-2: Will changes to water, aquatic prey and plant quality from combined developments affect wildlife health?	• During operation of combined developments, no significant health impacts were identified for wildlife health from exposures to water from the Athabasca or Muskeg rivers; however, there is some uncertainty regarding the chronic toxicity of naphthenic acids. This prediction is not significantly different from that predicted for the Muskeg River Project. • Following closure in the far future when equilibrium conditions have been established for all combined developments, a potential impact associated with chemicals in plants has been identified in the CEA. The residual impact is likely to be enhanced in the CEA, relative to the impact predicted for the Muskeg River Mine Project in so far as there is a greater likelihood on a regional basis for this exposure pathway to be realized, but likely without an increase in exposure magnitude.	• The same conclusion reached in the CEA with respect to the uncertainty of the chronic toxicity of naphthenic acids is applicable to the RDR.
HUMAN HEALTH ISSUES		
HHCEA-1: Will water quality changes from combined developments affect human health?	• During operation and closure, no significant human health impacts were identified; however there is some uncertainty regarding the chronic toxicity of naphthenic acids and the potential exposure pathways. The resulting impact prediction for the CEA is not significantly different from that predicted for the Muskeg River Project.	• No significantly increased exposures predicted due to RDR.
HHCEA-2: Will air quality changes from combined developments affect human health?	• During operation of the combined developments, no significant impacts to human health were identified from the following emission sources: mine fleet exhausts, fugitive emissions from tailings settling ponds, fugitive emissions from mine surfaces and background sources of PAH in residential communities.	• During operation of the regional developments, no significant impacts were identified to human health from the following emission sources: mine fleet exhausts, fugitive emissions from tailings settling ponds, fugitive emissions from cut mine surfaces, and background sources of PAHs in residential communities.
HHCEA-3: Will changes to air and water quality from combined developments affect human health?	• During operation, no significant impacts are expected. However, there is some uncertainty regarding the chronic toxicity of naphthenic acids and exposures to airborne emissions from upgrader stack sources, as discussed for HHCEA-1.	• During operation, no significant impacts were identified for human health through this multimedia exposure pathway. However, there is some uncertainty regarding the chronic toxicity of naphthenic acids as discussed for HHCEA-1.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
HHCEA-4: Will changes to plant and game meat quality from combined developments affect human health?	1. During operation and closure phases of the Muskeg River Mine Project, no significant impacts were identified for human health as a result of consumption of native plants or wild game. Increased air emissions predicted for the CEA scenario may contribute to an increase in chemical concentrations in plant and game tissues. Quantitative estimates of future tissue concentrations are unavailable to assess the impact.	• During operation and closure phases of the Muskeg River Mine Project, no significant impacts were identified for human health as a result of consumption of native plants or wild game. Increased air emissions predicted for the RDR scenario may contribute to an increase in chemical concentrations in plant tissues. A potential impact is therefore predicted for the RDR. Quantitative estimates of future plant tissue concentrations are unavailable to quantify the impact further.
HHCEA-5: Will equilibrium concentrations of residual chemicals in water and select local food items following reclamation of all developments affect human health?	• Following closure in the far future when equilibrium conditions have been established for all combined developments, a potential impact associated with chemicals in plants has been identified in the CEA. The residual impact is likely to be enhanced in the CEA, relative to the impact predicted for the Muskeg River Mine Project in so far as there is a greater likelihood on a regional basis for this exposure pathway to be realized, but likely without an increase in exposure magnitude.	• Following closure in the far future when equilibrium conditions have been established for all combined developments, a potential impact associated with chemicals in plants has been identified in the RDR. The residual impact is likely to be enhanced in the RDR, relative to the impact predicted for the Muskeg River Mine Project and those predicted in Section F12, in so far as there is a greater likelihood on a regional basis for this exposure pathway to be realized, but likely without an increase in exposure magnitude.
HHCEA-6: Will noise from combined developments during construction and operation unduly affect people who reside in the region?	• During construction and operation, truck and shovel operations of combined developments may cause periodic exceedances of permissible sound levels in Fort McKay. The residual impacts identified in the CEA are not significantly different from those predicted for the Muskeg River Mine Project , due to the mobile nature of noise sources, the ability to mitigate and the remoteness of several developments to Fort McKay.	• The residual impacts identified in the RDR are not significantly different from those predicted for the Muskeg River Mine Project and those predicted in the CEA, due to the mobile nature of noise sources, the ability to mitigate and the remoteness of several developments to Fort McKay.
RESOURCE USE ISSUES		
RUCEA-1: Will Combined Development Result in a Change in Surface and Mineral Extraction Use?	• Mitigation measures will reduce the impact to the surface disposition. However, some of the disposition (in this case the Athabasca River Valley) will still be affected.	• No effects were identified for the Project in the RDR over those discussed in Section F14.
RUCEA-2: Will Combined Developments Result in a Change in ESAs?	• The Kearl Lake ESA may be affected by changes in terrain, vegetation, or wildlife or by changes in access. Provided that this ESA is avoided to the extent possible and that appropriate mitigation measures are used to further minimize impacts, the cumulative impacts associated with the developments on this ESA will be minor.	• The Kearl Lake wildlife movement corridor may be affected by changes in terrain, vegetation and wildlife or changes in access. Provided that appropriate mitigation measures are used to further minimize impacts, the impacts associated with the various developments on ESAs will be minor.

Key Question/Environmental Issue	Cumulative Effects Assessment (CEA)	Regional Development Review (RDR)
RUCEA-3: Will Combined Developments Result in a Change in Forestry Resource Use?	• Some areas of merchantable timber will be lost due to project development. This impact cannot be mitigated. However, the degree of concern is **Low**, as these areas represent a very small portion of the total AAC. • In the long-term, forest production will be equal to, or greater than that which existed prior to the developments.	• Some areas of merchantable timber will be lost due to development. This impact cannot be mitigated. However, the magnitude of the impact is expected to be Low, as these areas represent a very small portion of the total AAC. • In the long-term, forest production will be equal to, or greater than that which existed prior to the developments.
RUCEA-4: Will Combined Developments Result in a Change in Hunting, Trapping, Fishing and Berry Picking?	• There will be a decrease in berry picking activities due to loss of berry picking habitat and restricted access. There are no mitigation measures for site clearing and restricted access. Following closure, however, important berry picking habitat can be restored and developed sites are returned to equivalent or greater capability. • A small proportion of hunting sites and some trapping areas will be lost due to changes in access and changes in wildlife abundance and distribution. Following closure, hunting opportunities will be similar to, or greater than that which existed prior to development. • Some fishing opportunities will be lost due to development of projects. In particular, restricted access will lead to reduced fishing opportunities and this impact cannot be mitigated. Following closure, fishing opportunities will be similar to, or greater than that which existed prior to development.	• A small proportion of hunting sites will be lost due to changes in access and changes in wildlife abundance and distribution. Following closure, hunting opportunities will be similar to, or greater than that which existed prior to development. • As indicated in the CEA, important berry picking habitat can be restored by careful restoration of the site, and many disturbed sites can be returned to equivalent or greater capability. • Some trapping areas may be lost as a result of project development (i.e., site clearing and restricted access). This impact cannot be mitigated. However, the loss in trapping opportunities should only exist during the life of the project under consideration. As well, trappers can be reimbursed for the loss of revenue. • Some fishing opportunities will be lost due to development of projects. In particular, restricted access will lead to reduced fishing opportunities, and this impact cannot be mitigated. Following closure, fishing opportunities will be similar to, or greater than that which existed prior to development.
RUCEA-5: Will Combined Developments Result in a Change in Non-Consumptive Recreational Use?	• Recreational areas along the Athabasca and Muskeg Rivers may be affected by changes in access and changes in terrain, vegetation and wildlife.	• The conclusion reached for the RDR and the same in the CEA.

STUDY AREA

This section summarizes the socio-economic impacts of the Muskeg River Mine Project. For this analysis, the study area is defined as the Regional Municipality of Wood Buffalo, containing:

- the urban service area of Fort McMurray, including Saprae Creek (referred to as the Fort McMurray area)
- the outlying communities of:
  - Fort McKay
  - Fort Chipewyan
  - Conklin
  - Janvier
  - Anzac
  - Gregoire Lake

ASSESSMENT METHOD

The socio-economic impacts of the Muskeg River Mine Project were assessed by comparing scenarios of the socio-economic conditions in the region with the project, and without the project. The difference between these scenarios is the impact of the project.

The base case (the scenario without the project) is defined as the socio-economic situation that would exist, assuming ongoing operation of the Syncrude and Suncor plants, as well as the approved Suncor Steepbank Mine and Trains 1 and 2 of Syncrude's Aurora North Mine.

The Shell Development Scenario (the scenario with the project) includes the cumulative effects of the base case and the Muskeg River Mine Project.

The regional development scenario includes the baseline, the Muskeg River Mine and announced projects that have not yet received regulatory approval.

ECONOMIC ACTIVITIES

The study area encompasses a range of economic activities, including:

- forestry
- mineral exploration
- conventional oil and gas development
- tourism

However, the economic backbone of the region is the oil sands industry.

FORT MCMURRAY AREA

The 1997 population of the urban service area of Fort McMurray was 38,700, an estimated 13% increase over the 1996 population. This growth reflects proposed projects by Shell, Mobil, Suncor, Gulf, Syncrude and others. It is in contrast to the stable population level in the area between 1986 and 1996.

Fort McMurray offers a full range of social services. Most service agencies are coping with the increased demand associated with the recent population growth.

The physical infrastructure of the Fort McMurray area is adequate. The water and sewer utilities, except the solid waste system, have sufficient capacity for the current and expected near-term population.

ISSUES

Fort McMurray Area Issues

Issues of particular concern to Fort McMurray residents are the:

- shortage of housing, particularly affordable housing
- rising cost of living, especially as it affects housing
- in-migration of people with low skills and limited resources looking for employment
- additional demands on many service providers

- disparity between the rural and urban service area of the municipality
- transportation, including highway traffic safety

Outlying Community Issues

The outlying communities are small hamlets, which have a limited range of social services. They depend on the Fort McMurray area for most secondary health care services and, except for Fort Chipewyan, for secondary education beyond the primary grades.

The issues of particular concern to residents in the outlying communities are:

- employment, training and business opportunities
- transportation to oil sands plants
- inadequate municipal and recreational facilities
- inadequate youth programs
- limited school system resources (human and physical)
- housing shortage and inadequacy
- municipal infrastructure inadequacy
- potential health problems from environmental pollution
- social issues, including:
  - family and child care
  - substance abuse
  - gaming

EMPLOYMENT

Construction Employment

The Muskeg River Mine Project will be mainly constructed between 1998 and 2002. Construction of the plant and associated infrastructure is expected to generate 1,900 work-years of work, excluding engineering. The number of workers is expected to peak at 1,300. Mine construction will require an estimated 500 work-years.

Long-Term Operations Employment

Based on preliminary estimates, the Muskeg River Mine Project will have a work force of about 800. Of these, about:

- 50% will work in the mine
- 40% will work in the extraction plant
- 10% will work in managerial, professional and administrative positions

Employment in the oil sands industry is the key determinant of population levels in the region, especially in the Fort McMurray area.

POPULATION IMPACTS

Urban Service Area

The long-term population of Fort McMurray, assuming the Shell Development Scenario, is estimated at:

- 37,900 in 2011
- 38,300 in 2016

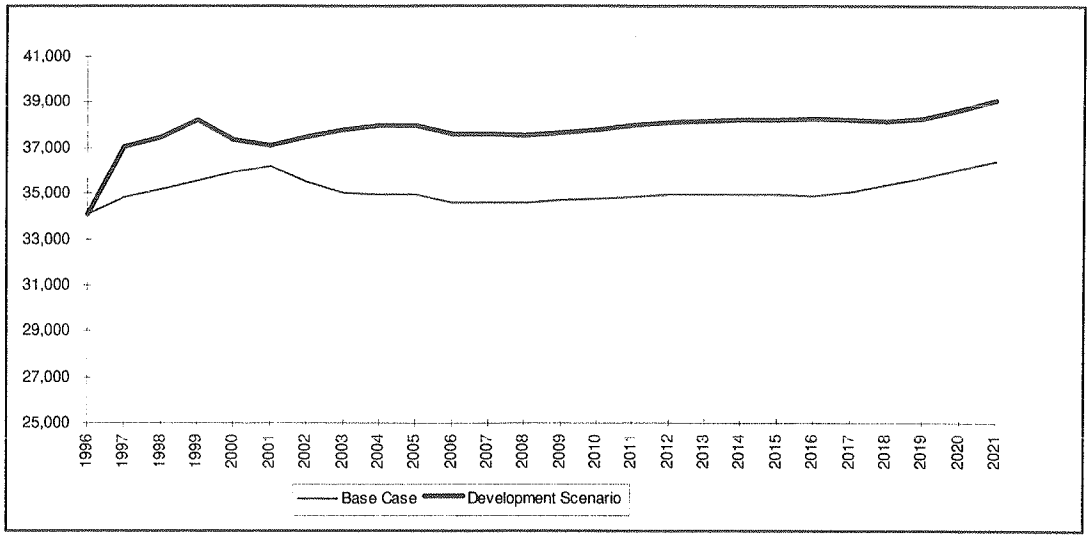
This is similar to the mid-1997 population estimate (see Figure 11-1).

The population is expected to increase during the construction period, peaking at 38,200 in 1999. This is about the same as the long-term population estimate.

Outlying Communities

Outlying communities might experience some in-migration, as community members who now live in Fort McMurray return, to avoid the increasing housing

costs. However, community members who become employed at the Muskeg River Mine Project might move to Fort McMurray to take advantage of commuter services.



Note: Base case includes existing oil sands plants, plus Steepbank and Aurora North mines.
The 1997 actual population is estimated at 38,700 and includes impact of expected projects.

Figure 3-1: Baseline Population Forecast in Fort McMurray Area

REGIONAL ECONOMIC BENEFITS

During the construction period between 1998 and 2002, Shell will invest about $1.2 billion. An estimated $230 million or almost 20% will accrue to local area people and businesses. During operations, the Muskeg River Mine Project is estimated to augment the labour and business income in the region by between $3 billion and $3.9 billion ($1997).

Fort McMurray Area

Much of the construction income will accrue to people and businesses in the Fort McMurray area, where most people live and where most businesses are located.

Outlying Communities

The outlying communities will also benefit from local spending during construction, through:

- employment of community members
- business income to community-based contractors

IMPACTS ON LOCAL AND REGIONAL SERVICE PROVIDERS

Housing

The population increase associated with the Shell Development Scenario translates into a demand for about 1,050 housing units. In the base case there are about 550 vacant dwellings, which, together with the almost 350 new housing starts in 1997, account for an estimated 900 dwellings. This suggests that most of the Shell-related housing demand will be met in the near future. No new rental accommodation construction has been announced, so rental accommodation will remain in short supply in the near term.

Mitigation

Shell plans to locate a full-service camp on Lease 13 during construction and will consider keeping part of the camp open during the operations phase.

Shell is working with the municipality on housing issues through the Mayor's Housing Task Force.

Education

The number of school-aged children associated with the Shell Development Scenario is expected to be between 800 and 900 students higher than the base case.

The school systems are expected to be able to deal with this increase by:

- re-opening a currently empty school
- adding temporary facilities, especially to schools in the Timberlea area, where most new houses are being built
- increasing busing for high school students

Mitigation

Shell has cooperated with other oil sands developers and the Regional Municipality of Wood Buffalo in developing an Urban Population Impact Model. This model estimates the population by age group, providing detailed planning input to the school boards in the area.

Shell is participating in the careers preparation program and is a member of the Training and Education Working Group.

Social Service Agencies

The long-term stable population of 38,000 to 39,000 associated with the Shell Development Scenario is expected to have less impact on social agencies than

the current population. Part of the current demand is from unqualified job seekers coming to the region, anticipating employment from the new projects.

Mitigation

Shell's key proposed mitigative measure is using a full-service camp throughout the construction period. For operations-phase workers, Shell is proposing an orientation program and a company-sponsored employee assistance plan.

To help individual agencies, Shell will develop a corporate charitable donations policy. Shell will consider establishing a 'days of caring program' to encourage employees to become active community volunteers.

Health Services

The impact of the population growth implied by the Shell Development Scenario is not expected to increase health service demands beyond those that are currently experienced. However, additional medical personnel need to be attracted to the area. Additional funds made available by Alberta Health for recruiting and retaining doctors in rural areas will help, but should be viewed in the context of the current physician deficit.

Mitigation

Shell will provide basic medical services for workers on site during the project's construction and operations phases. Four medical technicians with the appropriate facilities will ensure that those working at the mine have continuous basic emergency health service coverage.

Shell and the other oil sands developers have established the Athabasca Oil Sands Facilitation Committee, which coordinates regional cooperation. This committee has a full-time resource person, who will work with the Regional Health Authority to identify issues and potential solutions.

Emergency Services

The Shell Development Scenario is not expected to increase the expected population levels beyond the 38,700 level estimated for 1997. This scenario does not imply service demands beyond those currently experienced. However, a new fire and ambulance station in the area or an expansion of the existing station in Thickwood Heights might be required.

Mitigation

Shell will provide full-time emergency health services for workers on site. Medical personnel will have a fully equipped Advanced Life Support (ALS) ambulance for transporting patients. The mine will have on-site fire-fighting equipment and trained personnel. An emergency response plan will also be developed and implemented.

Shell will explore the possibility of a mutual aid agreement with the fire department of the Regional Municipality of Wood Buffalo and the emergency units of Syncrude and Suncor.

Highway Transportation

The Muskeg River Mine will require an average of five to eight trucks daily to deliver major equipment and materials during construction. Diesel fuel delivery will account for about 16 truck movements daily during operations. Additional traffic will be generated by the movement of people and materials during operations.

Mitigation

The measures Shell proposes to take to mitigate the impact of the Muskeg River Mine on traffic includes:

- using a camp for construction workers
- scheduling delivery of fuel, construction materials and equipment in off-peak periods
- considering alternative ways of delivering fuel
- busing workers
- discouraging construction workers from using private vehicles
- cooperating with other oil sands developers in scheduling shifts and work hours

Shell is working with other oil sands industry developers and the Regional Municipality of Wood Buffalo to define traffic issues further and to suggest remedial action. Shell, as a sponsor and member of the Athabasca Oil Sands Facilitation Committee, will support any of the committee's traffic issue recommendations.

Other Infrastructure

The population estimates associated with the Shell Development Scenario do not reach any critical municipal infrastructure thresholds. The change from a stable population to one of population growth, partly from the Muskeg River Mine development, has brought general infrastructure needs more into focus. The municipality is currently reviewing its infrastructure planning.

Mitigation

Shell will provide all necessary infrastructure on Lease 13, and is cooperating with other oil sands developers, the municipality and provincial politicians to identify infrastructure requirements and to formulate viable options.

MUNICIPAL FISCAL IMPACTS

The Muskeg River Mine will have a positive impact on the fiscal position of the municipality. The mine will contribute an estimated $1.25 million per year in municipal property taxes. In addition, new housing will add about $800,000 a year to municipal property tax revenue.

PROVINCIAL AND NATIONAL ECONOMIC IMPACTS

Income and Employment Impacts

Construction Phase — Income Impacts

An estimated $730 million (60%) of the construction expenditures will accrue directly to the provincial economy. Of the balance, $140 million (12%) is estimated to accrue to the rest of Canada and $370 million (38%) to foreign suppliers.

The income that will accrue to Alberta and the rest of Canada from the construction of the Muskeg River Mine will be compounded through the subsequent spending and re-spending of the new direct-income stimulus. The project will increase the province's gross domestic product (GDP) by an estimated cumulative $980 million, and increase household income by $680 million between 1998 and 2002.

Construction Phase — Employment Impacts

Design and construction of the Muskeg River Mine will require an estimated 3,000 work-years of direct employment. In addition, the construction expenditures will generate employment among suppliers (indirect employment) and across other sectors of the provincial economy (induced employment). The total direct, indirect and induced employment impacts to the province will equate to 6,600 work-years. Those employment impacts will be largely concentrated between 1998 and 2002.

Operations Phase — Income Impacts

An estimated $180 million to $240 million annually (80%) of the $225 million to $300 million operating costs, will be spent in Alberta. The total direct, indirect and induced income impacts to Alberta associated with operating the Muskeg River Mine are estimated at between $220 million and $280 million annually in terms of the province's GDP and between $110 million and $145 million annually in labour income.

Operations Phase — Employment Impacts

The operation of the Muskeg River Mine will require about 800 work-years annually. The direct, indirect and induced employment impacts in the province are estimated at 1,700 work-years annually.

Net Social Benefits

The undiscounted net social benefits of the Muskeg River Mine for the project's life are estimated to be $3.8 billion. Therefore, the project is of significant economic benefit to the provincial and national economies.

Between 1997 and 2025, $1.2 billion (33%) of the undiscounted net social benefits will accrue to the Alberta government and $850 million (22%) to the federal government — a total of 55% of all net social benefits. An estimated $30 million will accrue to the municipality as property taxes. The balance will go to the owners as a return on investment.

The estimated net social benefits do not account for additional municipal and government spending on infrastructure. These expenditures would decrease the net social benefits.

Other Impacts and Benefits

The development of the Muskeg River Mine will have other provincial economic benefits that are not reflected in the income and employment impact assessment or the net social benefit analysis. For example, the project will:

- support the province's goals to attract new investment and to diversify and sustain the economy
- contribute directly to the provincial resource revenue
- increase personal, corporate and other tax revenue through induced employment and economic activity
- contribute to the revised outlook on oil sands industry in the region. The industry would offset declines in the province's conventional oil industry.
- provide opportunities for Shell to apply new approaches and technologies in oil sands mining and bitumen extraction. These research and development initiatives are expected to yield increasing returns.

These qualitative economic benefits reinforce and augment the quantitative economic benefits.

CONSTRUCTION AND OPERATIONAL EMPLOYMENT

The regional impact assessment considers the Muskeg River Mine Project in the context of several other proposed projects. In addition to those assumed in the baseline, projects that have been announced, but that do not yet have regulatory approval, include:

- Suncor's Millennium Project
- Mobil Oil's Kearl Oil Sands Mine
- Gulf's Surmont Commercial Oil Sands Project
- Syncrude's Syncrude 21 suite of projects

Other in situ developments are planned, including projects by Petro-Canada and Japan Canada Oil Sands.

The estimated construction work force associated with these projects will peak at 7,500 workers in 2000. As several projects are in the early stages, these work force estimates are provisional. Cumulative new and additional operational work forces are estimated at about 2,700.

CUMULATIVE POPULATION IMPACT

Assuming that all the planned projects proceed, the cumulative population estimate for the Fort McMurray area is 47,100 by 2016. This estimate implies a 22% increase over the 1997 estimate. However, this estimate needs to be interpreted with caution, because all projects might not proceed, or other projects might be proposed.

During the construction period of most projects, the Fort McMurray area will have marginally higher population levels. The population is expected to peak at 48,900 in 2006, a 26% increase over the 1997 estimate.

The Fort McMurray area will also be influenced by the project site construction camps. The camps will draw on some central services. The total annual camp population is expected to peak at 6,300 in 2000.

The outlying communities are expected to grow, based on natural population dynamics. This includes the possibility that people will return to their communities to avoid the increasing cost of housing in the Fort McMurray area.

IMPACTS ON LOCAL AND REGIONAL SERVICE PROVIDERS

Housing

The regional housing demand is estimated at 3,800 dwelling units. Meeting this demand at current levels of building activity would take 11 years.

This imbalance in the housing market means that housing will remain in short supply during this 11-year period. Therefore, part of the population will continue to rely on basement suites and rental accommodation.

Education

The number of school-aged children is expected to increase from 8,300 in 1996 to 11,000 by 2002 and 11,300 by 2005. This increase of between 2,700 and 3,000 represents a 30% to 35% increase over eight years. Enrollments are expected to decline marginally as children graduate from secondary school.

This increase in school-aged children translates roughly to a need for 100 to 125 classroom teachers and associated facilities. The magnitude of the population increase is known. However, the timing of the impact depends on the age and family profile of the new workers attracted to the region.

Social Service Agencies

Social service agencies are already experiencing some impact from the population changes associated with regional development. If the expected regional development proceeds, the population will increase at 6.5% annually for the next five years and at 1% for the following five years. This population growth will have further impact on the demand for social services.

Several agencies expect a linear relationship between population and service demands. Others will experience impacts in the near-term construction phase, from speculative workers moving to the region.

Health Services

The total service population of the health region will likely increase by 2005 to 52,000, including:

- the Fort McMurray area
- outlying communities
- construction camps

The camp population might peak at 6,300 in 2000. The long-term stable population might reach 49,000 between 2016 and 2018, an increase of 7,000 (17%).

Without adjusting the analysis to the demand for individual services, the expected population level of 49,000 will require 60 to 65 physicians to keep the

number of patients per physician within the provincial average of 700 to 750. This implies an increase of at least 30 physicians more than the current 32.

Emergency Services

The expected population growth will increase demands for emergency services. Emergency resources will need to expand to meet these demands.

Highway Transportation

New jobs will increase the total number of vehicles on the highway north of Fort McMurray by an estimated 15% to 17% during the operations phases of the projects. Highway use will increase by up to 35% in 2000, when several projects will be in full construction. Much of this projected increase will conform to the current highway-use profile, thus increasing rush hour congestion.

Other Infrastructure

The population impact from regional development will remain below the critical level of 55,000 to 60,000, beyond which major municipal infrastructure expenditure is expected. However, projects included in the regional development will have some impact on the municipality. Some of these impacts are already being felt, such as a marked increase in development permit applications for residential, commercial and industrial construction.

MUNICIPAL FISCAL IMPACTS

A preliminary review of the fiscal impacts of the proposed projects suggest that they will lead to improvements in the municipal fiscal situation. The plants and mines are major contributors to the assessment base, although conveying relatively little direct cost to the municipality. This beneficial impact depends on the way the municipality wants to develop. Although still in an early stage of discussion, some major infrastructure options are being considered, including:

- a bridge over the Clearwater River
- opening up the area to the east of the Clearwater for development

These options could have a significant impact on the municipal fiscal position.