Shell Canada Limited

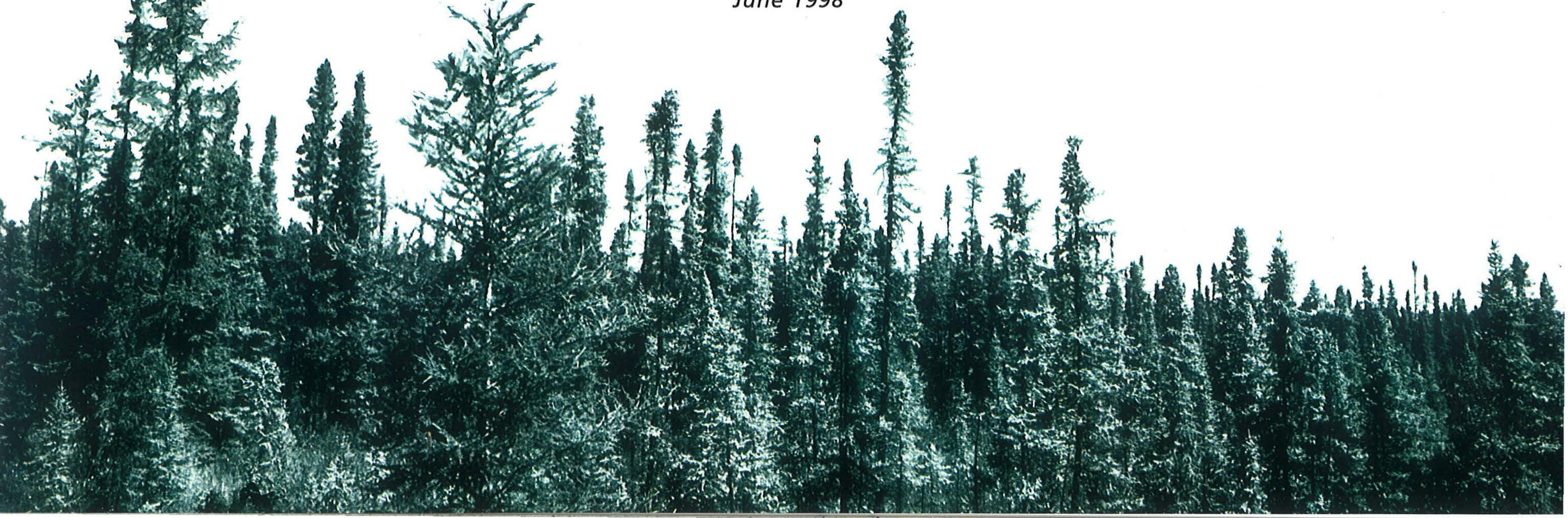
application for the approval of

MUSKEG RIVER MINE PROJECT

Supplemental Information

submitted to
Alberta Energy and Utilities Board
and to
Alberta Environmental Protection

Calgary,
June 1998



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June 29, 1998

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Re: Additional Information for Muskeg River Mine Project
EUB Application No: 970588
AEP Alberta Environmental Protection and Enhancement Act Application No: 001-20809
Water Resources Act File No: 60330

Shell Canada Limited is pleased to provide the Alberta Energy and Utilities Board (EUB) and Alberta Environmental Protection (AEP) with the additional information requested in your June 12 letter. Shell is also pleased to provide the requests for additional information received from the Department of Fisheries and Oceans and the Oil Sands Environmental Coalition, together with Shell's response.

In addition to the information requests, the Supplemental Information document for the Muskeg River Mine project includes:

- An update on several aspects of the planned project that have been modified since the application for the Muskeg River Mine was filed on December 19, 1997 as well as an update on public consultation activities and regional cooperation initiatives. This information has been provided in the Project Update at the front of the enclosed Supplementary Information document.

- A summary of the types of issues of interest to the community of Fort McKay and the kind of information that Shell is providing to this community through the agreement that Shell has in place with the Fort McKay leadership for reviewing the project.

- Additional approval requests that were inadvertently omitted in the December, 1997 project filing have been included in the Supplementary Information document. These requests require AEP approval under the *Environmental Protection and Enhancement Act* (EPEA) and the *Water Resources Act* .

- Additional environmental information, such as information on how the end-pit lake discharge will be managed, the potential effects and the mitigation and monitoring program that Shell will put in place to protect the Muskeg River and Athabasca River. The long-term surface water and aquatic resources monitoring and research in the region are also described, including how local effects in the Muskeg River Basin and regional effects in the Athabasca River will be monitored, and the research programs that Shell is recommending be implemented in the region. The results of ozone modeling studies conducted in the region are included, and the information on the predicted volatile organic compound emissions provided in the original application have been updated. Additional information on traditional land use and baseline information on outlying communities is also provided.

- Errata corrections for the original project and EIA submissions.

We trust that submission of this additional information fulfils the EUB and AEP's requirement for information on Shell's Muskeg River Mine Project, enabling the review of the application to be completed in a timely way.

Please direct all communications regarding this application to:

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Respectfully submitted on June 29, 1998.

Yours truly,

Neil Camarta
Vice-President, Oil Sands

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OVERVIEW

PURPOSE

Shell Canada Limited (Shell) filed its Application for Approval of the Muskeg River Mine Project with the Alberta Energy and Utilities Board (EUB) and Alberta Environmental Protection (AEP) in December 1997. Since then, Shell has continued to develop the project scope. Meanwhile, the EUB and AEP, as well as a number of other key stakeholders, have reviewed the application and requested additional information on Shell's project application.

This Supplemental Information submission for the Muskeg River Mine has been prepared to satisfy the information needs of the EUB, AEP, Department of Fisheries and Oceans (DFO) and other stakeholders. Shell is also addressing stakeholders' concerns through its comprehensive consultation process and will continue to meet with stakeholders to understand and resolve their issues.

Shell will also be providing an addendum to this Supplemental Information by mid-July with responses to questions and comments received from Environment Canada, the Department of Indian Affairs and Northern Development (DIAND) and Parks Canada.

SCOPE OF SUPPLEMENTAL INFORMATION SUBMISSION

The Supplemental Information submission has been broken into four main parts:

- Part 1 – Project Update
- Part 2 – Environmental Information
- Part 3 – Errata
- Part 4 – Information Requests and Responses

PROJECT UPDATE

The Project Update is intended to provide:

- information on any substantive changes made to the project basis since the December 1997 submission

- an efficient forum for providing information of common interest to stakeholders

The key areas of information in the Project Update are:

PROJECT UPDATE (cont'd)

- geology
- mining
- facilities
- public consultation

Geology

The geology update (see Section 2) reflects additional information obtained during the 1997 to 1998 winter field program. The new data was applied to the geological model and confirmed the geological interpretations submitted in the application. The new data was also used to recalculate resource estimates. The results are consistent with resource estimates provided in the application.

Mining

The mining update (see Section 3) reflects changes in the mine plan resulting from the 1997 to 1998 winter field program. This section also includes information about the:

- overall mine plan
- resource estimates
- disposal and storage areas
- tailings settling pond
- details of the bridge design and the Muskeg River crossing to the south disposal area
- lease boundary management

Utilities and Infrastructure

The utilities and infrastructure update (see Section 4) provides information about the changes to the utilities and infrastructure basis, including:

- the development of the utility and offsite details
- linkages to regional cooperative development activities
- recommended Athabasca River water intake location, structure and design
- revised material and energy balances

A key element of the Muskeg River Mine development is the engineering, construction and operation of an experimental oil sands pilot facility to confirm bench-scale pilot information and generate commercial design information for Shell's oil sands extraction process. Shell applied to the EUB under Section 11 of the *Oil Sands Conservation Act*, and to AEP under the *Environmental Protection and Enhancement Act, Approvals Procedure Regulation* for approval to construct an experimental processing pilot facility on Lease 13. These approvals were received in December 1997.

The pilot plant is a fully integrated, 20 t/h facility with equipment for:

Utilities and Infrastructure (cont'd)

- feed preparation
- oil sands conditioning
- primary extraction
- froth deaeration
- froth treatment
- tailings handling

The objectives of the pilot plant are to:

- provide an integrated pilot of the preferred technology to generate scale-up data for front-end engineering in 1998 and detailed engineering in 1999
- confirm bitumen recoveries and quality under various operating conditions
- generate data on Lease 13 oil sands to optimize design and linkages to mine and tailings disposal commercial design

The range of technical parameters assessed will correspond to the design features described for the extraction process in the application for approval (see Volume 1, Section 5). The pilot plant represents a major financial commitment in meeting these objectives with projected costs in excess of $20 million for constructing and operating the facility.

The pilot engineering was finalized in early 1998. The plant has now been constructed and is being commissioned. The intent is to run the pilot through most of 1998, and potentially beyond, depending on the information requirements.

Project Execution

Since December 1997, little has changed on the execution plan for the mine, extraction plant and infrastructure. The scope of work remains essentially the same and will continue until a requirement for change is identified and verified by operating the pilot plant.

The engineering, procurement and construction management contractor for the commercial project is currently being selected and the selection is expected to be finalized in mid 1998. Front-end engineering and design will begin in August. The main focus of this work will be process design and equipment selection based on results from the pilot plant. Additional engineering and estimating activities will follow to provide the detailed feasibility estimate.

The intent continues to be to construct the camp, access road, water supply, power supply, sewage treatment and office during the summer of 1999, so that these facilities can be used at full capacity for the entire construction season for the main process facilities in 2000. Sufficient lead time for engineering and procurement must be available after project approval for this work to take place.

Public Consultation

Public consultation continues to be a priority for Shell. The public consultation update (see Section 5) provides information on consultation activities from January 1998 to mid-June, including information on:

- major consultation activities
- First Nation and Metis activities
- industry regional cooperation activities
- issue-resolution sessions with stakeholders

ENVIRONMENTAL INFORMATION

In addition to the Project Update, the Muskeg River Mine Supplemental Information submission contains updated and new environmental information, including:

- AEP approval information
- EIA information
- socio-economic information

AEP Approval Information

The AEP Approval Information section (see Section 6) clarifies and augments the description of activities and approvals being sought from AEP under the *Environmental Protection and Enhancement Act* (EPEA) and the *Water Resources Act.* Also included are requests for additional approvals, such as approval for:

- a Class 2 landfill
- withdrawal and diversion of surface water and groundwater for process water and other uses
- withdrawal and diversion of groundwater for potable water use
- a fenceline permit for all water-related activities

EIA Information

This EIA Information section:

- describes how the end-pit lake discharge will be managed, including the potential effects of releases into the Muskeg and Athabasca rivers and the mitigation and monitoring program that Shell will put in place to protect the quality of water in these rivers

EIA Information (cont'd)

- outlines the long-term surface water and aquatic resources monitoring and research in the region, including how local effects in the Muskeg River Basin and regional effects in the Athabasca River will be monitored, and the research programs that Shell is recommending be implemented in the region

- provides the results of ozone modeling studies conducted in the region

- updates the predicted volatile organic compound emissions information provided in the original application

- provides (in Appendix A) the results of a Traditional Land Use Study prepared for Shell by Fort McKay Environmental Services Ltd.

Socio-Economic Information

This section augments the socio-economic information provided in the application by:

- providing baseline information on outlying communities
- summarizing the issues in these communities
- outlining the impacts that the project is expected to have on each community

ERRATA

The errata provides a list of errors and omissions by application and EIA volume.

INFORMATION REQUESTS AND RESPONSES

This part of the Supplemental Information provides information requests from regulators and other stakeholders and Shell's responses to those requests. Specifically, responses are provided to the following regulators:

- the EUB – The key issues discussed relate to:

  - the Application Process
  - Mining
  - Resource Definition
  - Muskeg River Resources
  - Tailings Site Alternatives
  - Tailings Management
  - Extraction
  - Utilities
  - Groundwater
  - Regional Development

- AEP – The key issues discussed relate to:

INFORMATION REQUESTS AND RESPONSES (cont'd)

- Assessment Requirements
- Air Quality and Noise, including Emissions, Proposed Bitumen Extraction Process, Greenhouse Gas Measurement, Mine Clearing and Slash Burning Emissions, Particulates, Ambient Air Quality, Acidifying Emissions, and Air Related Monitoring Activities
- Geology, Terrain and Soils
- Vegetation and Resources Assessment, Biodiversity, and Ecosite Analysis
- Wildlife Assessment, Health and Monitoring
- Water, including Hydrogeology, Water Quality and Quantity, Muskeg River, and End-Pit Lake
- Aquatic Resources
- Reclamation and Closure, including Closure Planning and Landscape Design, Biodiversity, Revegetation, and Land Use
- Public Health
- Historical Resources
- Socio-Economics

- the Department of Fisheries and Oceans (DFO) – The key issues discussed are:
  - the Muskeg River Crossing
  - the Athabasca River Water Intake
  - Habitat Displacement
  - Surface Water Quantity, Water Releases, Hydrology and Hydrogeology
  - Thermal Impacts
  - the Regional Aquatics Monitoring Program
  - Groundwater Diversion and Dewatering
  - Basal Aquifer Drawdown
  - Aquifer Exchange
  - End-Pit Lakes
  - Contaminants and Toxicity
  - Fish Health Tainting
  - Acidifying Depositions
  - Impact Assessment

In addition to the information requests and responses to regulators, Shell is addressing the issues raised by:

INFORMATION REQUESTS AND RESPONSES (cont'd)

- Fort McKay – Shell has been meeting with the community of Fort McKay since spring, 1997, to discuss the Muskeg River Mine Project. Shell and the leadership of Fort McKay have a formal agreement in place which outlines the process for reviewing and providing feedback on the proposed project. This includes the sharing of project information, obtaining feedback from the community on socio-economic and environmental issues, and a forum for resolving issues.

- the Oil Sands Environmental Coalition (OSEC) – Shell has had an ongoing relationship with OSEC since September 1997, to review the environmental aspects of the Muskeg River Mine application for approval. As part of this ongoing process, Shell has provided responses to an extensive issues list that was submitted to AEP as part of OSEC's Statement of Concern on March 25, 1998. Shell's goal in providing responses to OSEC is to address OSEC's concerns and help focus concerns on key issues.

Shell is also working with a variety of other stakeholders, such as Environment Canada, Parks Canada and Mobil Oil Canada Properties, through its comprehensive consultation process, and will continue to meet with stakeholders to understand and resolve their concerns.

REGIONAL COOPERATION

SCOPE

Shell is committed to exploring and advancing regional cooperation within the oil sands industry with the goal of recovering the resource in an economically efficient and environmentally acceptable manner. This can be challenging, given differences in organizations' investment schedules, geographic proximity between development locations, and project objectives. It must also be done within the context of Alberta's current policy of encouraging new operations in oil sands development. Shell will continue to focus energy in this area to capture mutually beneficial opportunities. This subject provides a brief update of Shell's approach to regional cooperation.

ENVIRONMENTAL MANAGEMENT

Shell continues to participate in collaborative efforts on environmental management with other oil sands companies, governments and other stakeholders. Shell will become increasingly involved as the project advances through the regulatory approval stage toward the development and, finally, the operations phase. Specific areas of involvement that Shell continues to participate in are:

- the Wood Buffalo Environmental Association (WBEA) — previously the Regional Air Quality Coordinating Committee (RAQCC) — as an observer
- the Regional Aquatic Monitoring Program (RAMP) — the 1998 surface water and aquatic resources program was recently designed and the spring field component completed
- the Hydrology and Climatic Monitoring Program — Syncrude and Shell are jointly developing this program for the Muskeg River watershed in 1998
- CONRAD — Shell continues to be an active participant in collaborative technology research through CONRAD. Shell will participate in a subgroup of CONRAD called the Terrestrial Reclamation on Challenging Material Research Program (TERRE), which is led by Syncrude and Suncor, to coordinate and consolidate all reclamation research.
- the Oil Sands Regional End Land Use Committee — In January 1998, the committee reported on its recommendations on baseline data required for end land use decision making, end land uses that will be allowed in the region and guidelines for prioritization. The committee also recommended methods for coordinating the preparation of reclamation plans through an advisory

ENVIRONMENTAL MANAGEMENT (cont'd)

committee, consisting of regulatory agencies, industry and other stakeholders.

- the Vegetation Reclamation Committee — Shell participated in the preparation of the terrestrial vegetation reclamation manual, which was finalized in May 1998
- the Wetlands Working Group — Shell is currently participating in preparing a wetlands reclamation manual
- the Athabasca Oilsands Cumulative Effects Working Group — the results of this coordinated industry and stakeholder work on cumulative effects methodology were incorporated into Shell's cumulative effects assessment. The cumulative effects study (CES) initiative continues, and has been linked with Regional Infrastructure Working Group activities to ensure a coordinated and ongoing focus. A framework document is being prepared, and a threshold workshop, which included participation by stakeholders in the region, was held in March 1998. The participants of the working group have signed an agreement to share environmental baseline data and project information for completing the CEA analyses.
- Ozone Modeling — Shell, Syncrude and Sunoco are jointly funding the modeling of regional ozone concentration using the new CALGRID model.

SOCIO-ECONOMIC DEVELOPMENT

The Regional Infrastructure Working Group (RIWG) and the Senior Level Athabasca Oil Sands Facilitation Committee continue to provide focused and coordinated vehicles for identifying and providing input on Wood Buffalo Regional Planning Group issues and needs. These two groups provide a central focus for industry, political and regional interest groups to work together constructively. Key focus areas for these groups include:

- coordinating project information and defining socio-economic implications
- transportation
- education
- employment

This central focus has provided Shell with a beneficial broader industry perspective. Shell will continue to actively support and work with these groups.

Shell is also participating in discussions with the Athabasca Tribal Council and other industries to address regional aboriginal issues. These discussions have taken place between senior company executives and the chiefs of the First Nations in the Wood Buffalo Region. A process is being developed to address regional aboriginal issues related to socio-economic opportunities and environmental impacts.

MINE PLANNING COORDINATION

Geological and mine reviews and alignment is ongoing between the staff of the companies that share common lease boundaries. The Muskeg River Mine shares a lease boundary with Syncrude's Aurora North development and steps have already been taken to harmonize the placement of utility infrastructure along this boundary, including:

- roads
- tailings lines

To date, no issues have been identified that negatively impact or conflict with Shell's Muskeg River Mine or Syncrude's Aurora Mine and closure plans. Mine plan coordination work will continue for the Muskeg River Mine through the planning, execution and operations phases.

Lease Boundary Management

Shell is developing a Lease Boundary Agreement framework to address harmonization and management of lease boundaries. The objectives are to:

- maximize the recovery of economic ore at the boundary
- equalize economic costs and benefits between the parties
- conduct a situation analysis to establish the best economic solution

Discussions have taken place with Syncrude and Mobil in the context of an industry wide forum to address general principles and protocols for the recovery of economic resource at lease boundaries. The desire has also been to involve the EUB staff in ongoing and timely reviews to ensure their input is captured in the development of the lease boundary harmonization agreement framework.

Shell and Syncrude have also undertaken a specific study related to lease boundary management between the Muskeg River and Aurora North mines. The study includes:

- defining and integrating the mine development plans
- analyzing options
- recommending optimum plans for lease boundary management

In concert with this activity, the implications of extending mining operations beyond a lease boundary, and the implications to the Oil Sands Royalty Regulation, will also have to be addressed. If potential changes appear to be required, Shell will consult with the regulators to assess and define them.

UTILITIES AND INFRASTRUCTURE

Cogeneration

Shell and Syncrude considered developing coordinated cogeneration facilities to take advantage of the thermal requirements at the Muskeg River Mine. This would have resulted in generating electrical power in excess of Shell's needs, with the resulting potential to supply electrical power to Syncrude. This option was not explored beyond the screening stage as Syncrude has pursued arrangements that integrate and optimize utilities between its Aurora and Mildred Lake facilities. Shell continues to evaluate cogeneration as an alternative to the case of Alberta grid-connected power presented in the application for approval.

The potential for coordinated electrical transmission is still being explored with Syncrude. Discussions have been initiated on the prospect of sharing access to its proposed transmission line from Aurora North to Mildred Lake. Shell would still require a second transmission line to ensure adequate reliability for power delivery from the Alberta grid.

Natural Gas Infrastructure

An industry working group has been established to define and explore the provision of:

- cost effective, reliable and efficient mainline infrastructure to the area
- specific project natural gas pipeline connections

This work is in progress and involves:

- Shell
- Syncrude
- Petro-Canada
- Mobil

Location of Roads and Utility Corridors

Since April 1998, Shell has been working closely with Syncrude to refine the location of the road and utility corridors through Lease 13 to the Aurora North site. This coordinated effort includes evaluating the locations of:

- Aurora froth and water pipelines
- Simmons gas pipeline
- electrical power transmission line
- roads

The Muskeg River and Aurora North development plans have been reviewed to ensure that neither will be compromised through the placement of facilities. Appropriate understandings have been established to ensure that future relocation will address development plans, particularly resource recovery.

PROJECT MANAGEMENT AND EXECUTION

A formal relationship has been established between the Shell and BHP Muskeg River Mine Project Manager and the Aurora General Manager. These managers are expected to stay in close contact throughout their projects' planning and execution phases. Coordinated management will help to:

- identify opportunities as execution advances
- identify and mitigate potential problems

OTHER LEASE HOLDERS

Early in 1998, Shell and Birch Mountain Resources Ltd. developed an understanding and arrangement to promote information sharing for the mutual benefit of the respective developments. A commitment was made to share geological and geophysical information on the leasehold interests in the Athabasca Region. A mechanism was also established to provide ongoing contact between the parties.

Initial discussions have begun with Alberta-Pacific Forest Industries Inc. on clearing timber from the initial development area. These discussions will continue as the project develops, to integrate clearing requirements with Alberta-Pacific's timber harvesting schedule.

Discussions have also been held with other regional operators, such as Suncor, Syncrude and Koch Canada, on amending the existing timber charge assessment tables in favour of a more representative value. Discussions with government continue, and will involve Alberta-Pacific and Northland Forest Products Limited in future, regarding:

- timber charge assessments
- annual operating plans
- the impact of Shell's Muskeg River Mine Project

SCOPE

Between November 1997 and March 1998, a winter field program was conducted in the western portion of Lease 13, to confirm and re-assess the commercial mining application for the Muskeg River Mine.

The work included:

- completing 109 oil sand evaluation core holes
- completing 227 shallow auger holes
- conducting about 95 km of electromagnetic (EM) and seismic ground surveys, to supplement the ongoing geological interpretation between core hole sites

CORE HOLE PROGRAM

Core holes were located in areas where the previous resource information was either insufficient or sub-standard (see Figure 2-1). These areas are:

- disposal areas (24 holes)
- tailings settling pond (26 holes)
- initial mine area (22 holes)
- other (37 holes)

The program involved standard core recovery with conventional downhole wireline logging methods. The standard suite of logs included gamma, resistivity, density and dipmeter. Sonic logs were also run at 34 core locations to provide calibration for the seismic program.

All core was geologically described, then sampled and analyzed using the Dean & Stark laboratory method (water and solids measured, bitumen by difference).

AUGER DRILLING PROGRAM

The auger drilling program was completed to provide additional information on the Quaternary deposits above the McMurray Formation. These deposits were penetrated using solid stem augering (103 sites) and hollow stem (split spoon) sampling (124 sites) for visual geological interpretation and selected index property tests.

AUGER DRILLING PROGRAM (cont'd)

The locations are summarized as follows:

- core hole locations (129 holes)
- tailings settling pond area (61 holes)
- other (37 holes)

All 1998 samples were geologically coded and incorporated into the overburden database. About 1,900 overburden drill holes are now included in the database and were remodeled at a much higher vertical interval resolution. The new overburden model allows detailed visualization of the distribution of post-McMurray facies.

No significant resource differences were identified from the information provided in the application for approval.

ELECTROMAGNETIC AND SEISMIC GROUND SURVEYS

The 95 km of electromagnetic and seismic ground surveys were carried out in conjunction with the drilling program. Currently, the surveys are being interpreted to supplement the ongoing geological modeling process. When this material is available, Shell will review it with the EUB.

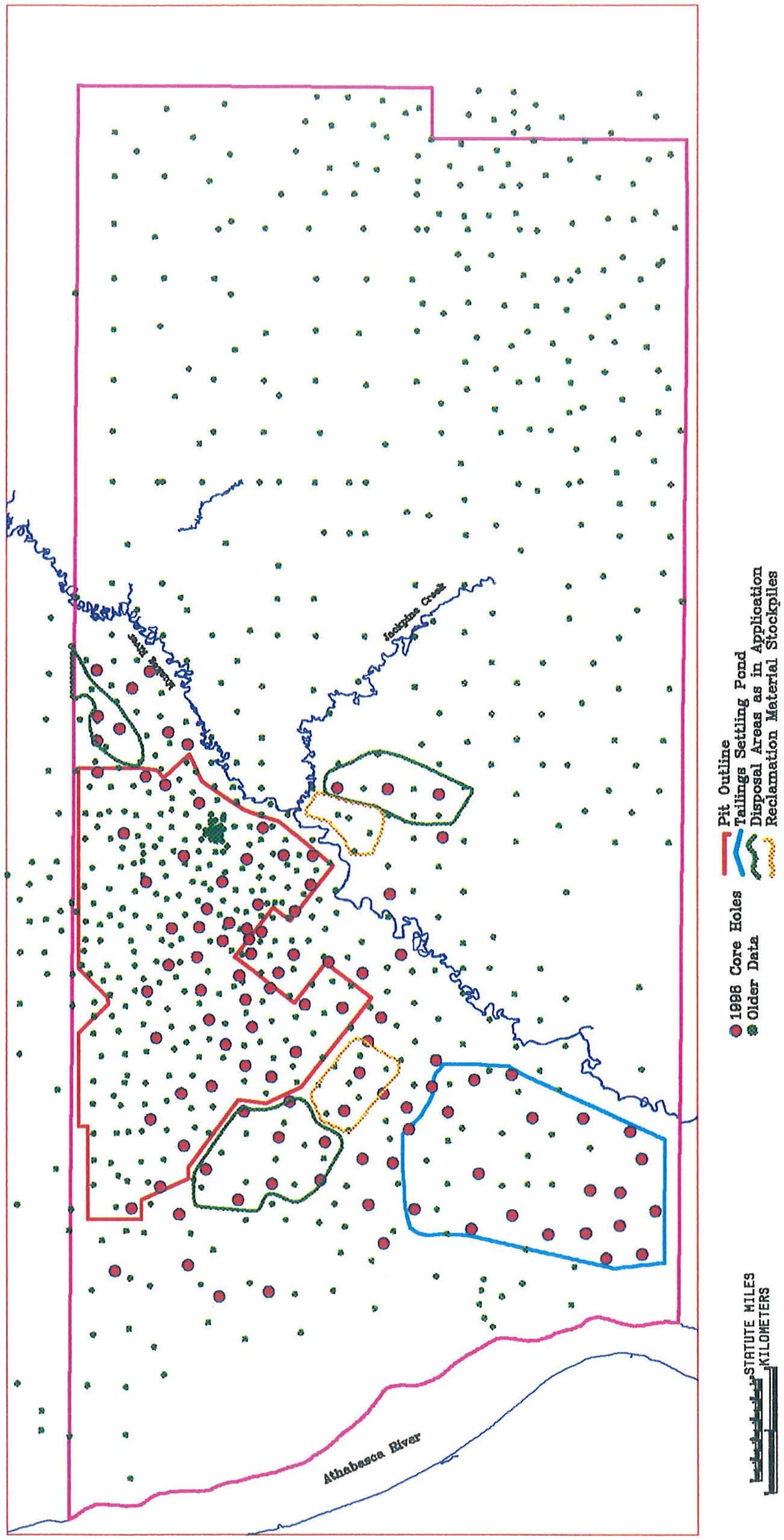


Figure 2-1: 1998 Core Hole Locations

GEOLOGY UPDATE

GEOLOGICAL MODEL

Bitumen analytical results and geological facies codes for all 1998 wells were incorporated into the geological model and compared with the information provided in the application. The model cited in the application appears to have been robust and highly predictive, because no significant trend reversals were observed. Confirmation and infilling of the data population has in some cases provided the necessary confidence to re-interpret or replace redundant vintage data.

GEOLOGICAL INTERPRETATIONS

Geological interpretations of the updated resource plans and sections are shown in:

- Figure 2-2 (a plot of TV/BIP (total volume/bitumen in place) showing Syncrude pits)
- Figure 2-3 (a plot of waste:ore with a 7% cut-off)
- Figure 2-4 (a plot of total ore thickness with a 7% cut-off)

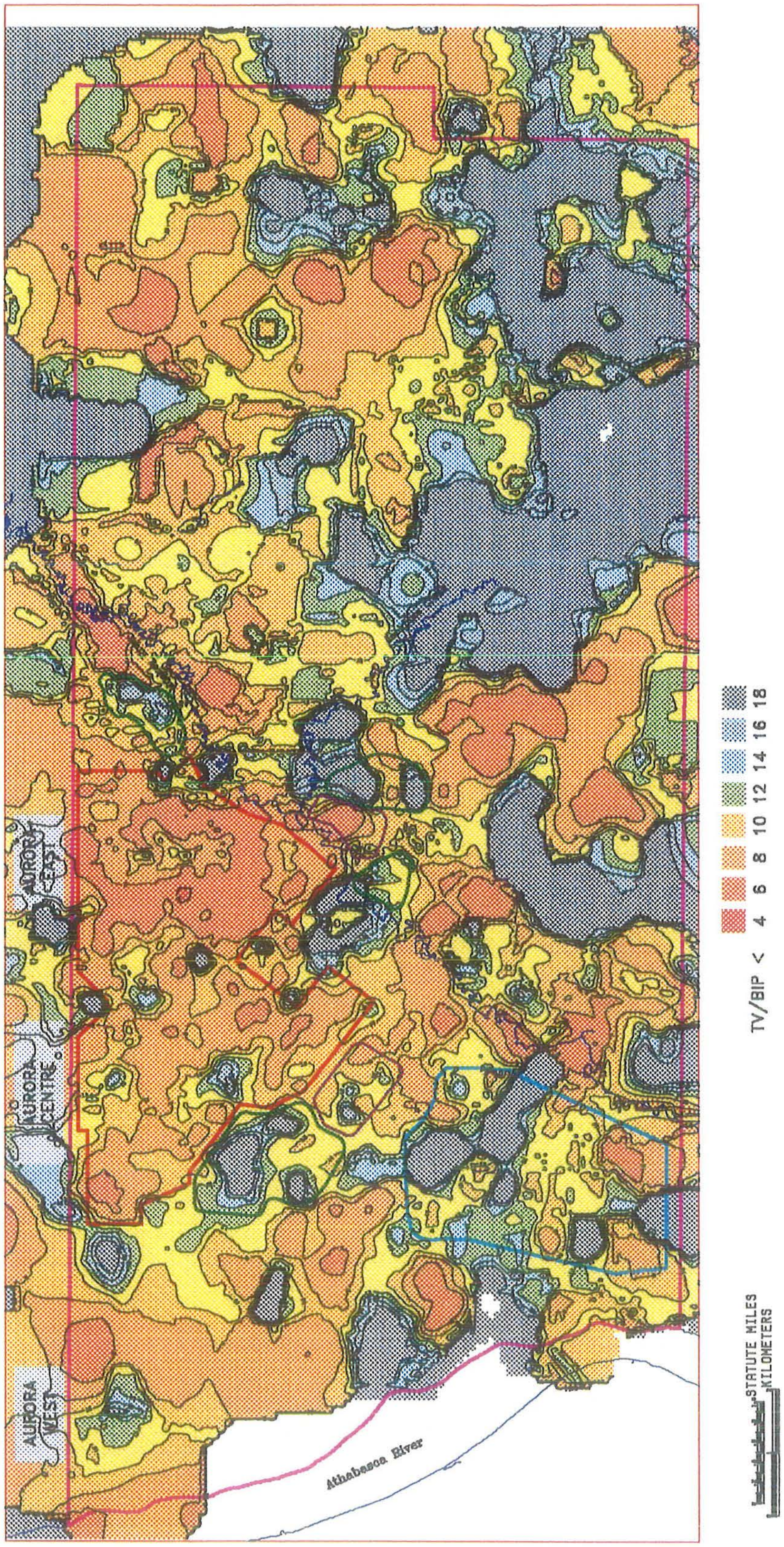


Figure 2-2: TV/BIP

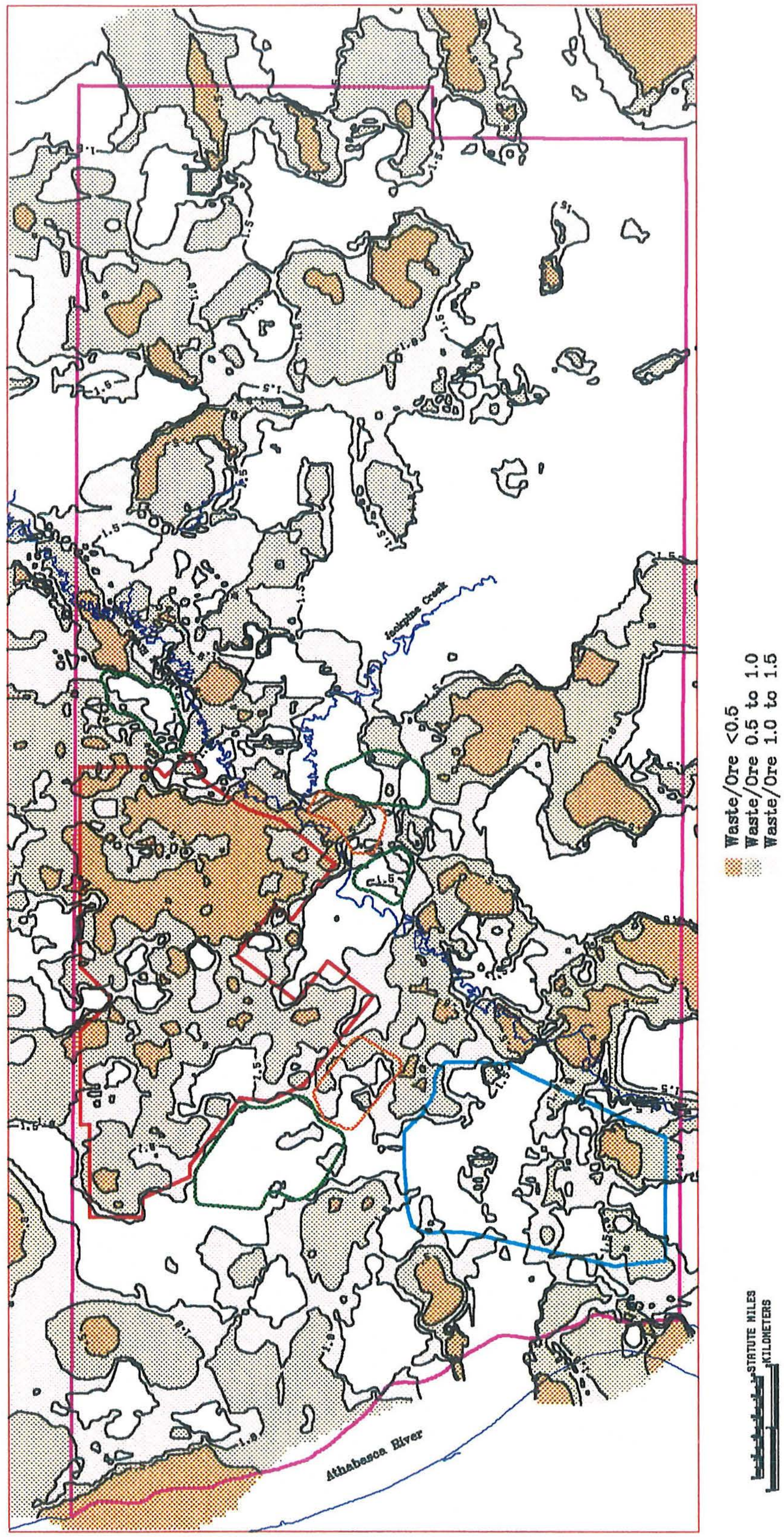


Figure 2-3: Waste:Ore (7% Cut-Off)

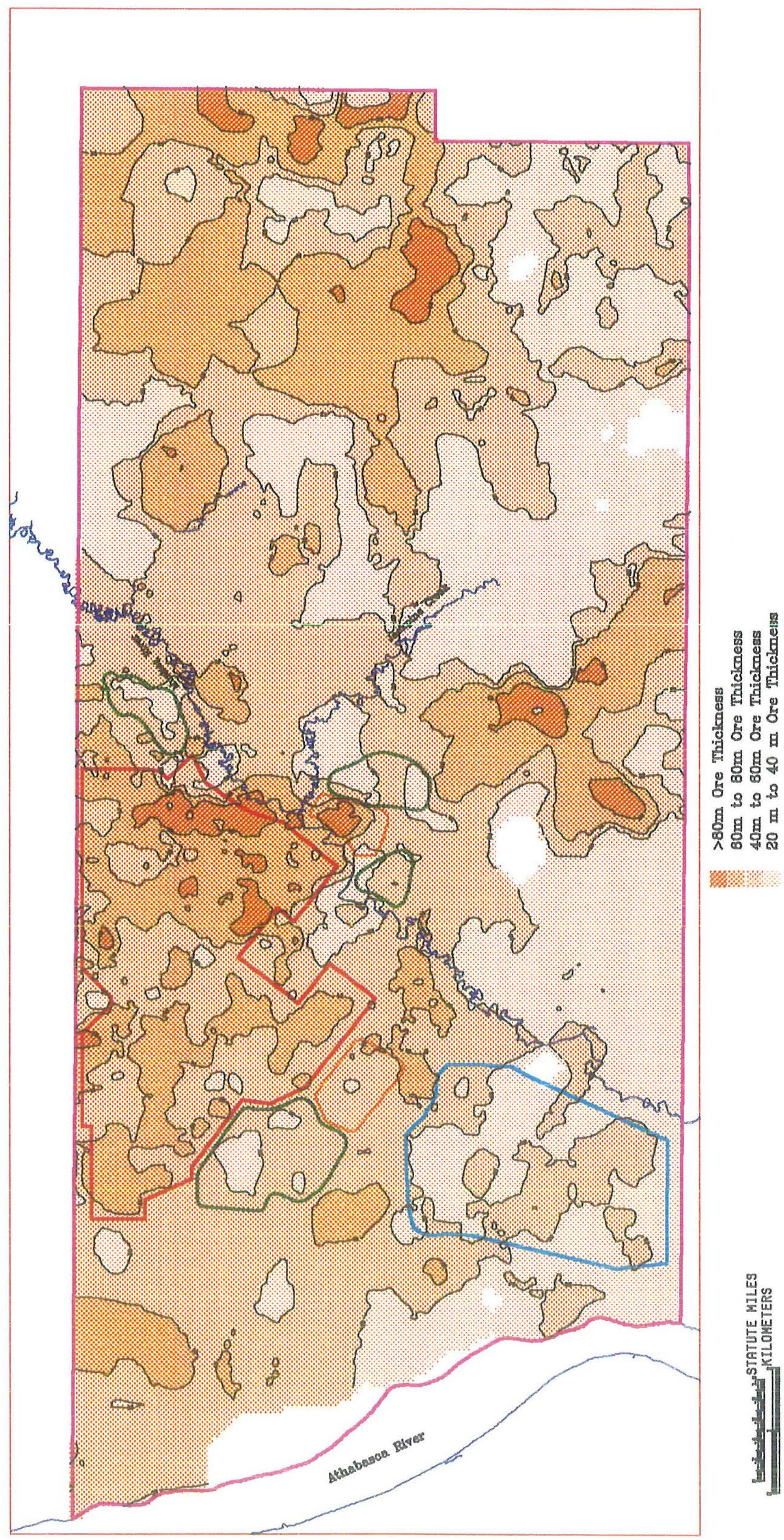


Figure 2-4: Total Ore Thickness (7% Cut-Off)

MODEL USED

The Lease 13 resource was re-calculated using the Landmark *Stratamodel* system, applying similar criteria and methodology (e.g., variable search distance averaging less than 500 m) to those described in the application. Included in the updated estimates are the results from the 1997 to 1998 program and subsequent geological interpretation.

TOTAL RESOURCE

See Section 3.2 for the updated resource values for Lease 13. The results are consistent with resource estimates provided in the application.

RESOURCE MODELING OF MINING AREA

Drilling within the main mining area provided additional confidence in the geological interpretation and detailed orebody characteristics. Resource modeling of the following key economic parameters is consistent with the details provided in the application:

- waste to ore ratio
- average bitumen grade
- TV/BIP

WEST DISPOSAL AREA

Drilling results in the west disposal area provided improved definition of the geology, with no significant changes.

SOUTH DISPOSAL AREA

Additional drilling in the south disposal area revealed some potential for economic ore at the southern end of the proposed disposal area. General geological trends in the area include:

- undulating Devonian surface at an average elevation of 200 m (85 m depth)
- moderate to thick (40 m) muddy centre reject
- thin (0-15 m) bitumen bearing tidal channel sands
- relatively uniform presence of fluvial channel sands (25 m thick) with about less than half of the sand thickness containing ore grade bitumen

The interplay between the trend of tidal channel sands and bitumen content of fluvial channel sands creates a variable trend in the TV/BIP ratio. The three holes proposed within the south disposal area were intended to delineate a north-south linearity with poor oil sand development. However, the following geological features were observed:

- low grade trends in the north area
- a narrow cross-trending sand that bisected the south disposal area
- a high grade orebody that continues to the southeast

NORTHEAST DISPOSAL AREA

The northeast disposal area is characterized by low grade and intermittent continuity of ore. General geological trends in the area include:

- a low Devonian basin (105 m to 120 m deep) in the immediate vicinity of the disposal site, which becomes 65 m deep toward the northern lease boundary and 35 m deep eastward, beneath the Muskeg River

NORTHEAST DISPOSAL AREA (cont'd)

- tidal channel sands that are uniformly 10 to 15 m thick across the area with bitumen grades in the ore at 9 to 11%
- fluvial channel sands that are 15 to 25 m thick, but contain no bitumen
- centre reject that is quite thick (up to 35 m) in areas where the Devonian is low
- resource potential largely controlled by the presence of bitumen-saturated sands among the flats facies above the tidal channel sand. Where these higher sands occur, they usually contain low-grade bitumen.
- average grade of ore that is 9% to 10% over most of the disposal area

Three holes were spudded in and around the originally proposed northeast disposal area. However, most of these wells encountered better than average oil sand development in the flats zone in addition to the tidal channel ore. The average bitumen grade is low, but the presence of this ore translates into a TV/BIP under 8.

Four holes were spudded within 1 km south of the disposal area. This confirmed a pre-existing area of thin tidal sands with below-average bitumen content, combined with an absence of bitumen-bearing sands above.

TAILINGS SETTLING POND

The 1998 winter drilling program provided additional information in the tailings settling pond area, increasing the drilling density to about 10 holes per section. Interpretation of the drilling results in this area revealed that:

- neither the tidal nor fluvial channel ore zones are well developed in this area. The sand sequences are thin and broken by many muddy bands.
- the centre reject can be moderately thick (more than 20 m) and includes discontinuous bituminous sands
- the Devonian basement is close to surface (less than 25 m) in the south, resulting in the complete absence of fluvial channel sand over much of the southern half of the tailings settling pond area. This sand laps onto the Devonian slope and thickens northward.
- ore trends counteract one another. As the fluvial channel ore thickens northward, the tidal channel ore thins from a maximum of 30 m and becomes increasingly patchy. The tidal channel sands exceed 20 m in thickness over only about 35% of the tailings settling pond area.

TAILINGS SETTLING POND (cont'd)

- there appears to be some high-grade ore close to the surface at the southeast of the tailings settling pond, mostly as a result of a thin sand deposition. However, the fragmented, discontinuous nature of the ore distribution in the tailings area is not amenable to economic mining.

SUPPLEMENTARY ILLUSTRATIONS

PURPOSE

The following supplementary illustrations are provided in response to the EUB's request for 1:20,000 scale plans. These plans are available in digital format, on request.

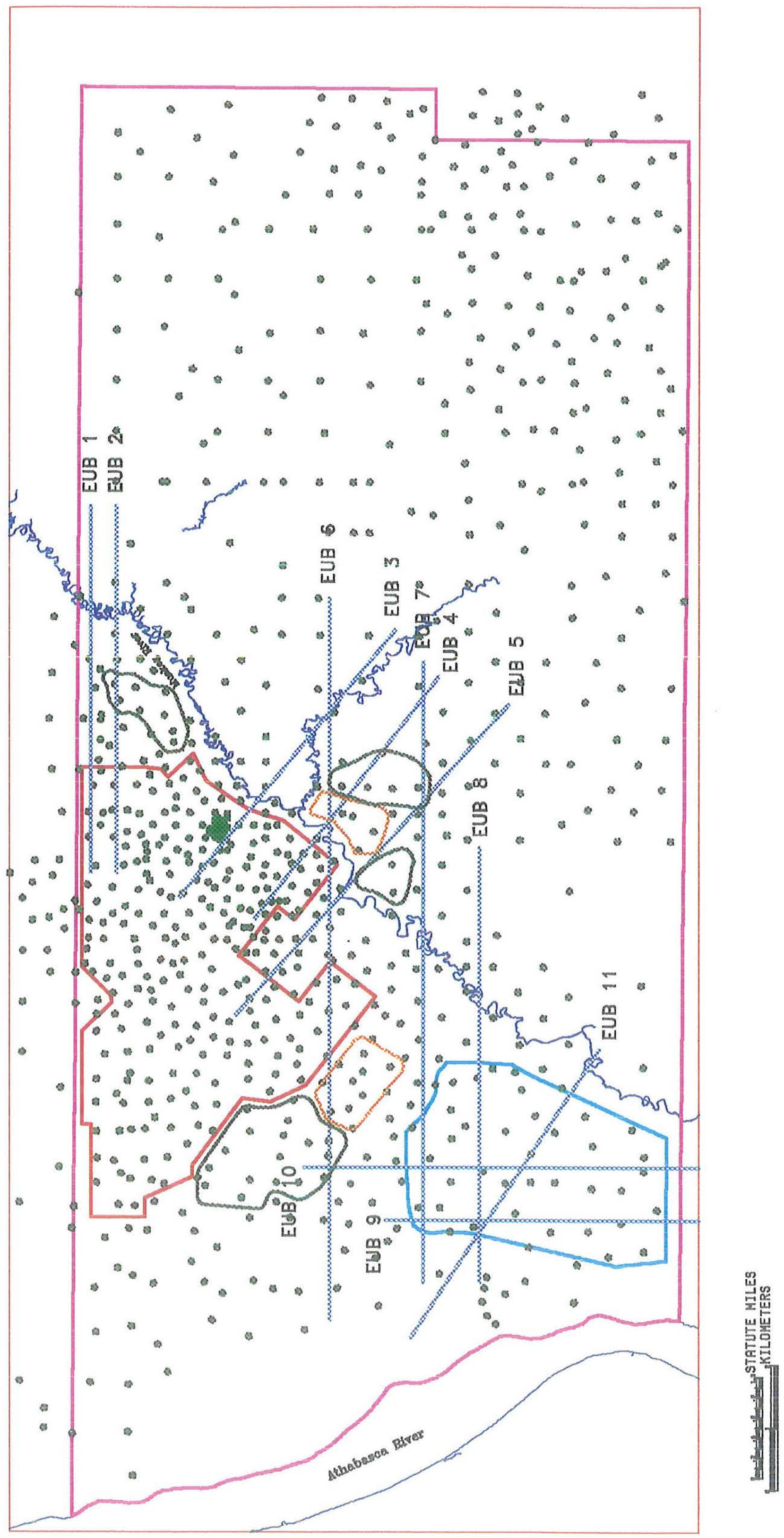


Figure 2-5: Location of Requested Geological Cross-Sections

Figure 2-6: Geological Cross-Section 1

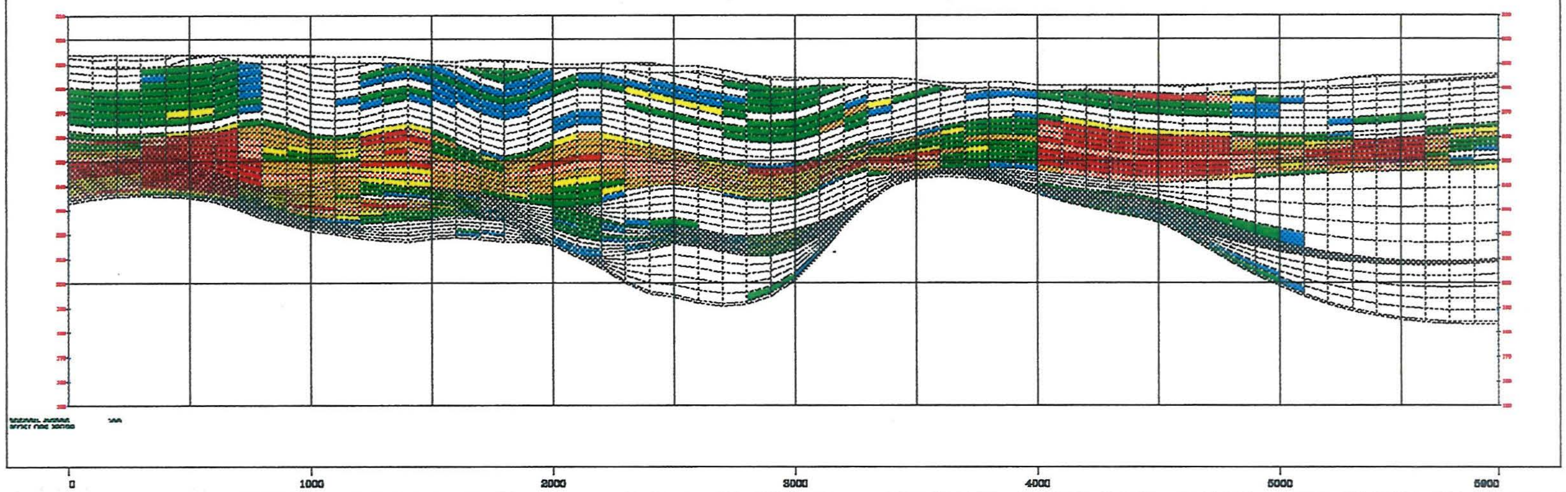


Figure 2-7: Geological Cross-Section 2

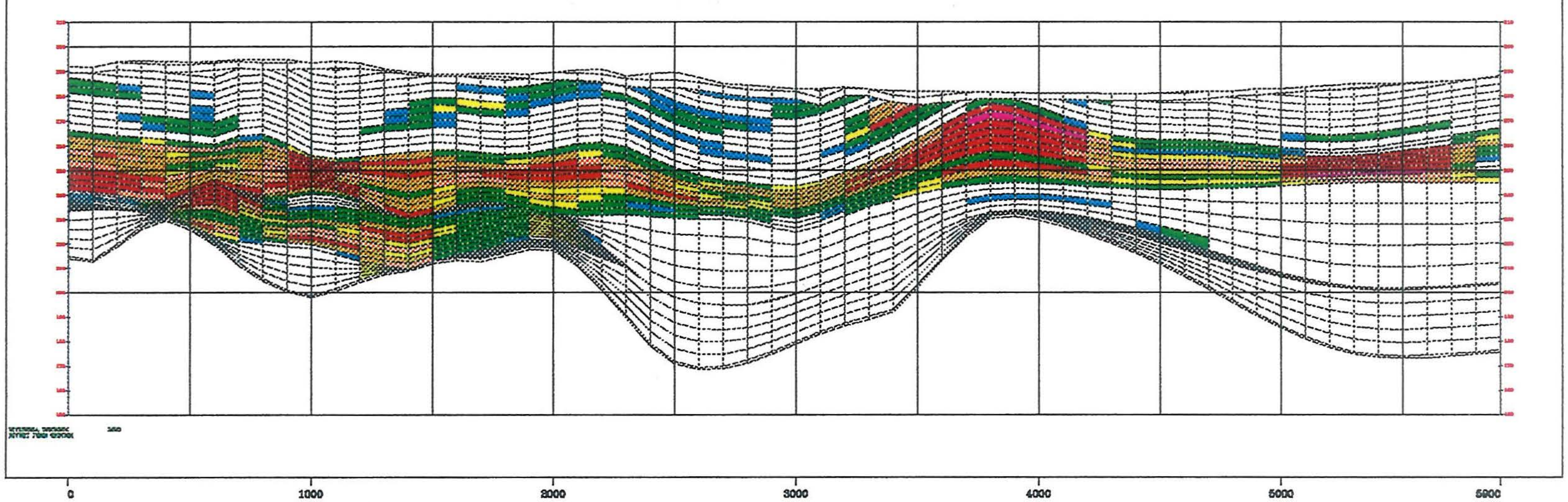


Figure 2-8: Geological Cross-Section 3

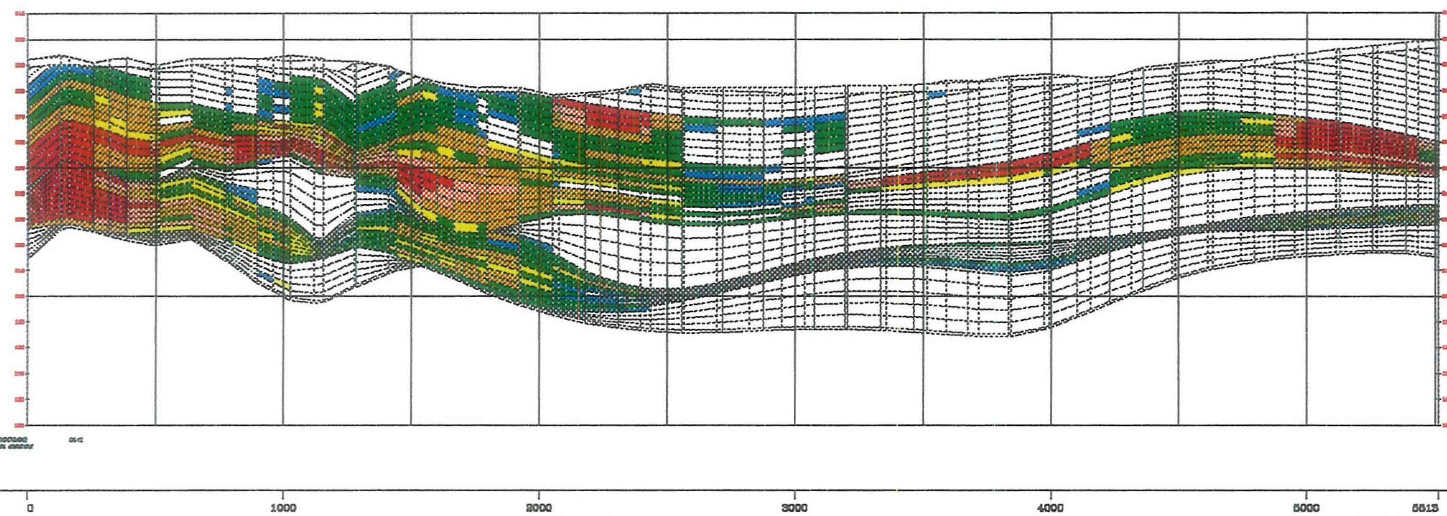


Figure 2-9: Geological Cross-Section 4

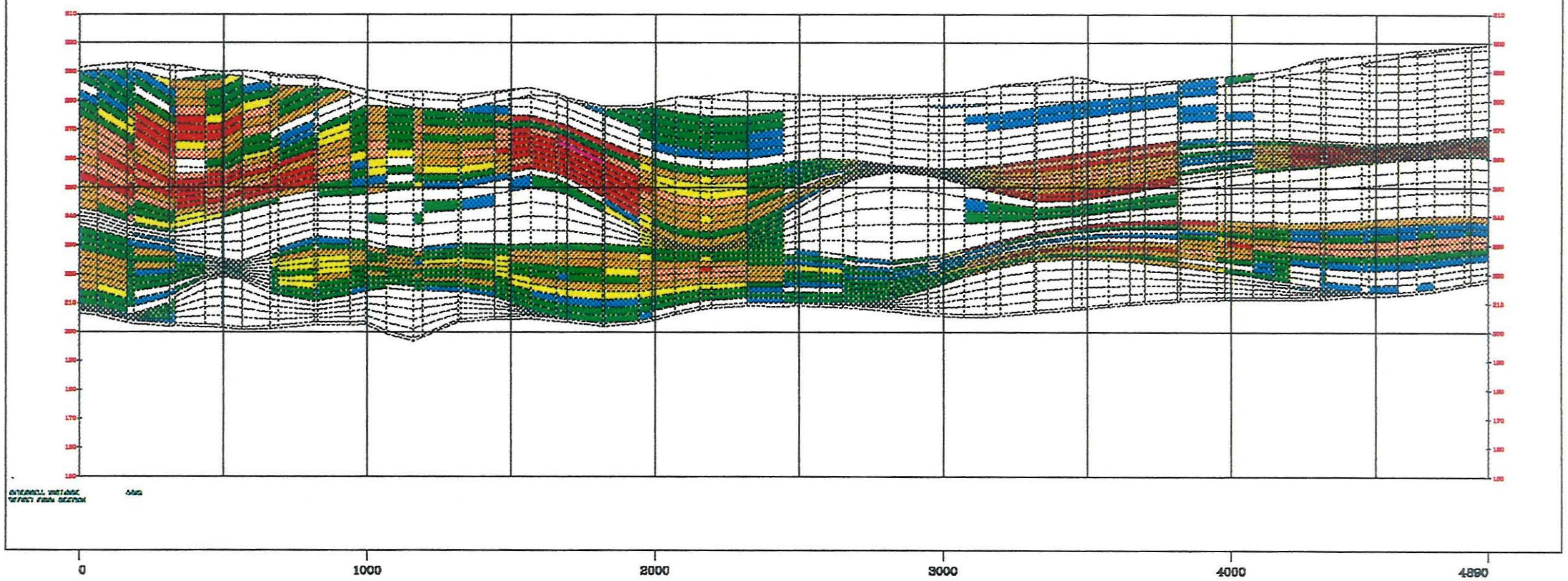


Figure 2-10: Geological Cross-Section 5

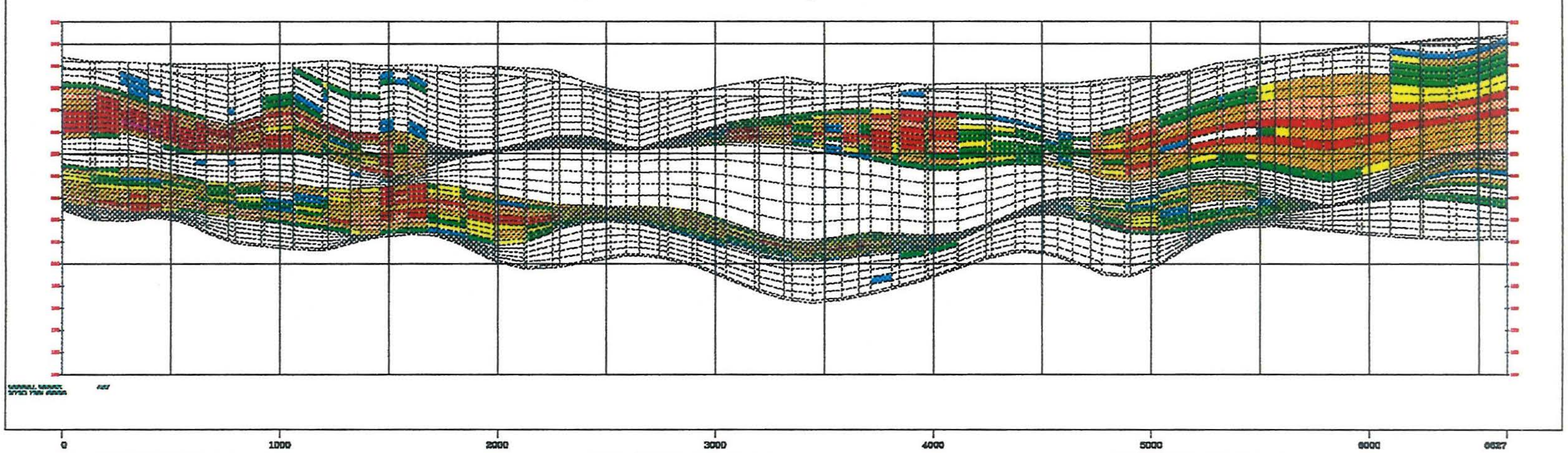


Figure 2-11: Geological Cross-Section 6

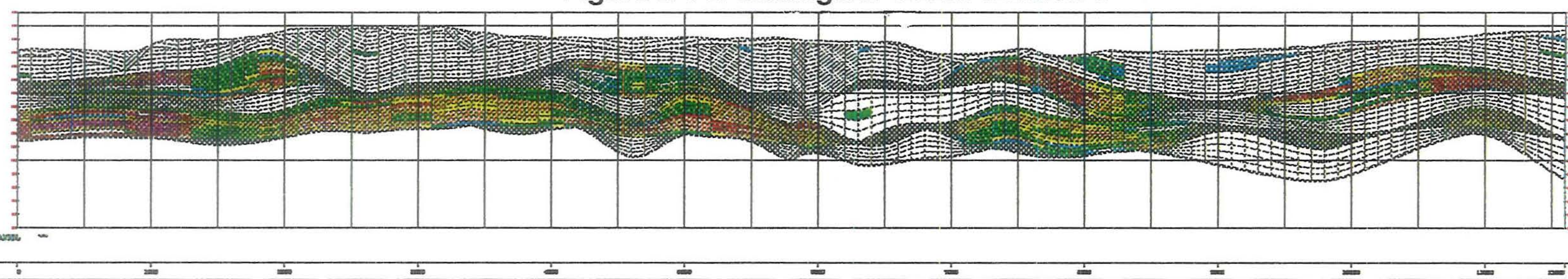


Figure 2-12: Geological Cross-Section 7

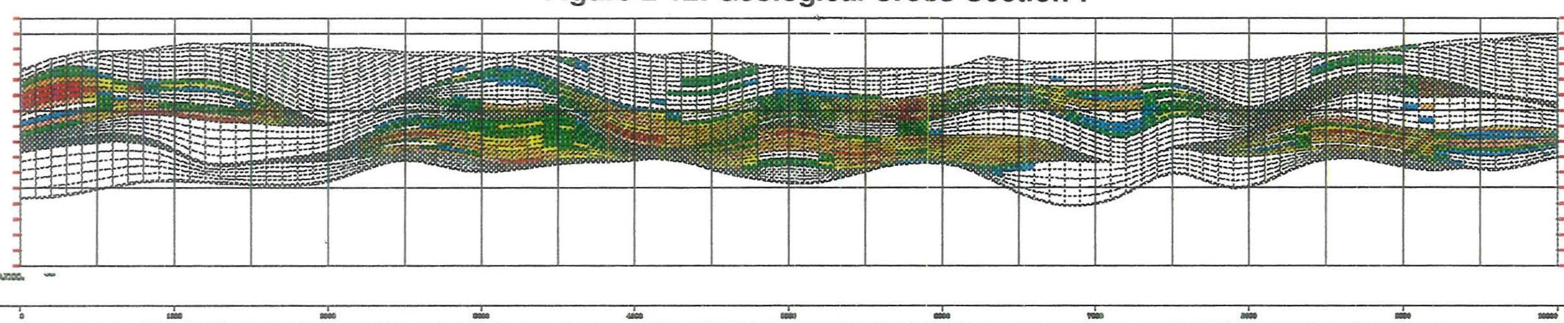


Figure 2-13: Geological Cross-Section 8

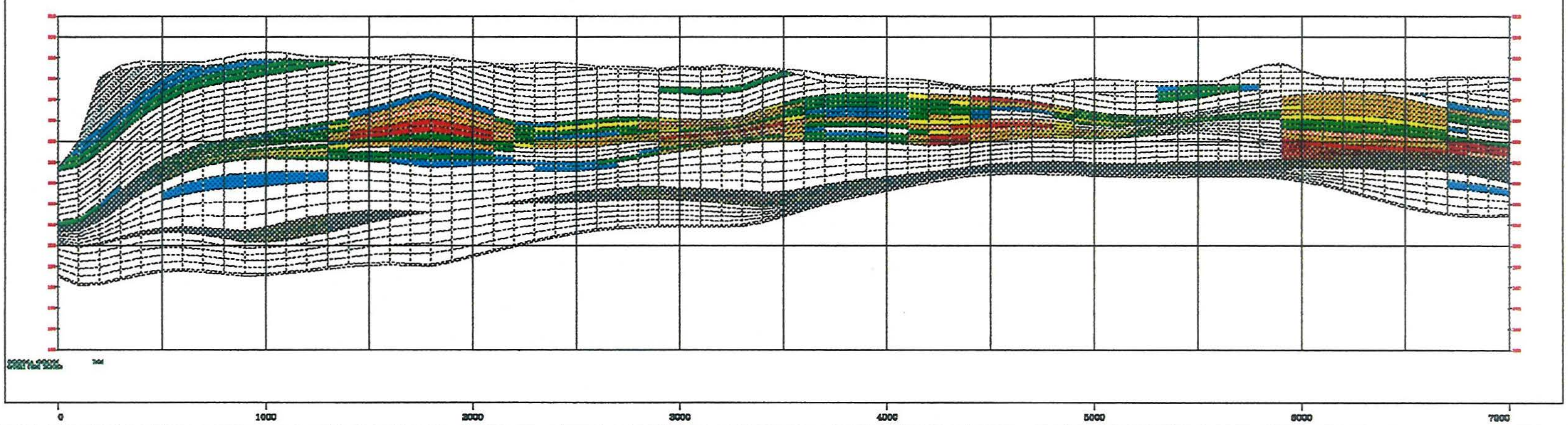


Figure 2-14: Geological Cross-Section 9

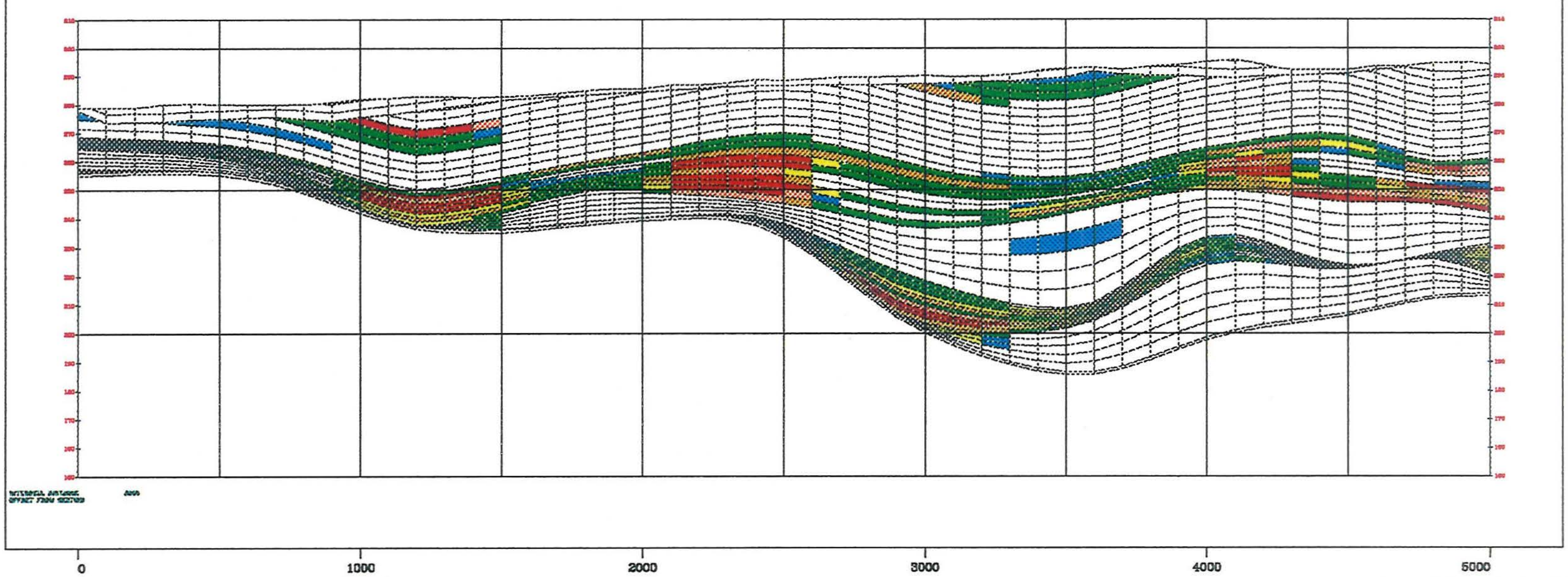


Figure 2-15: Geological Cross-Section 10

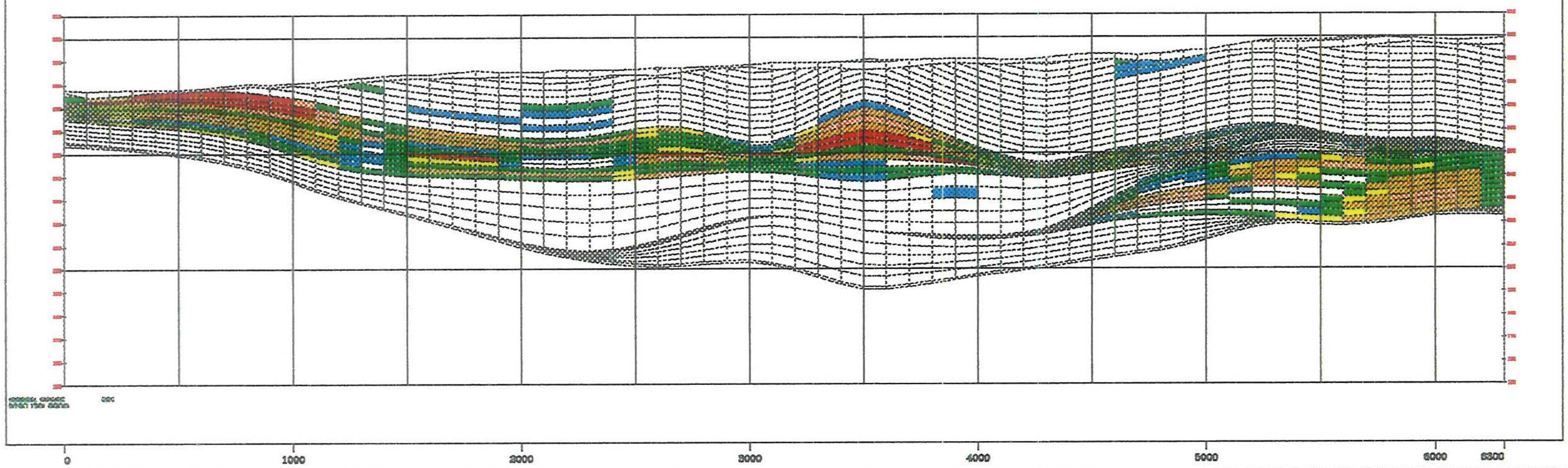
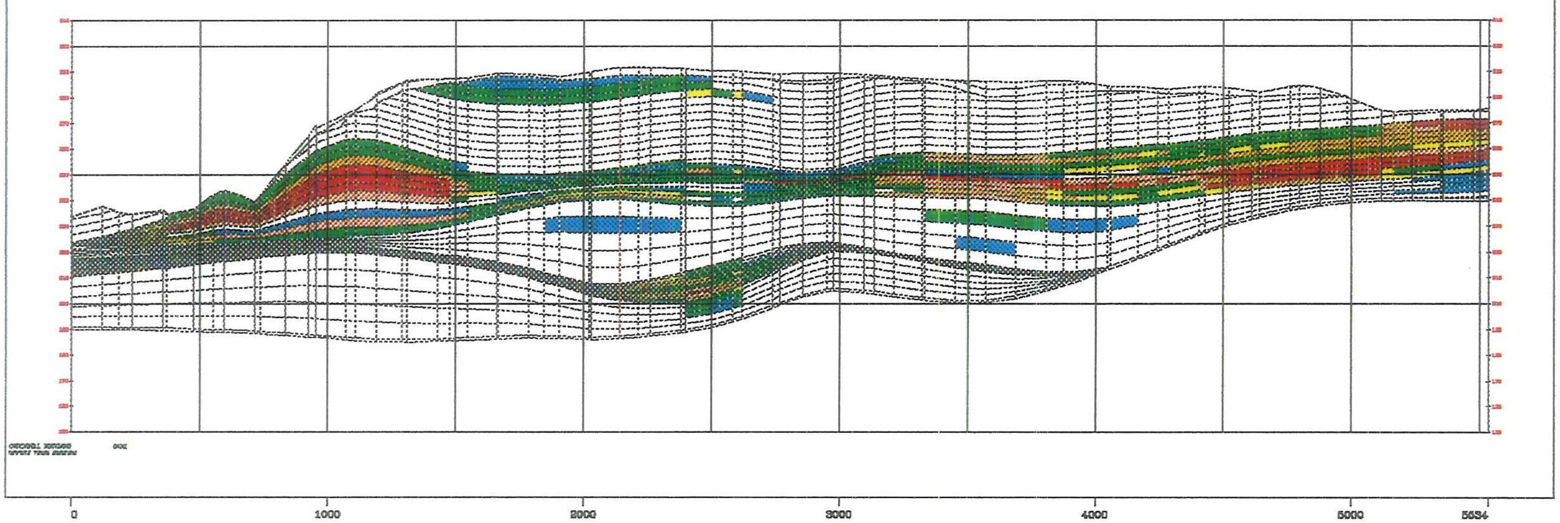


Figure 2-16: Geological Cross-Section 11



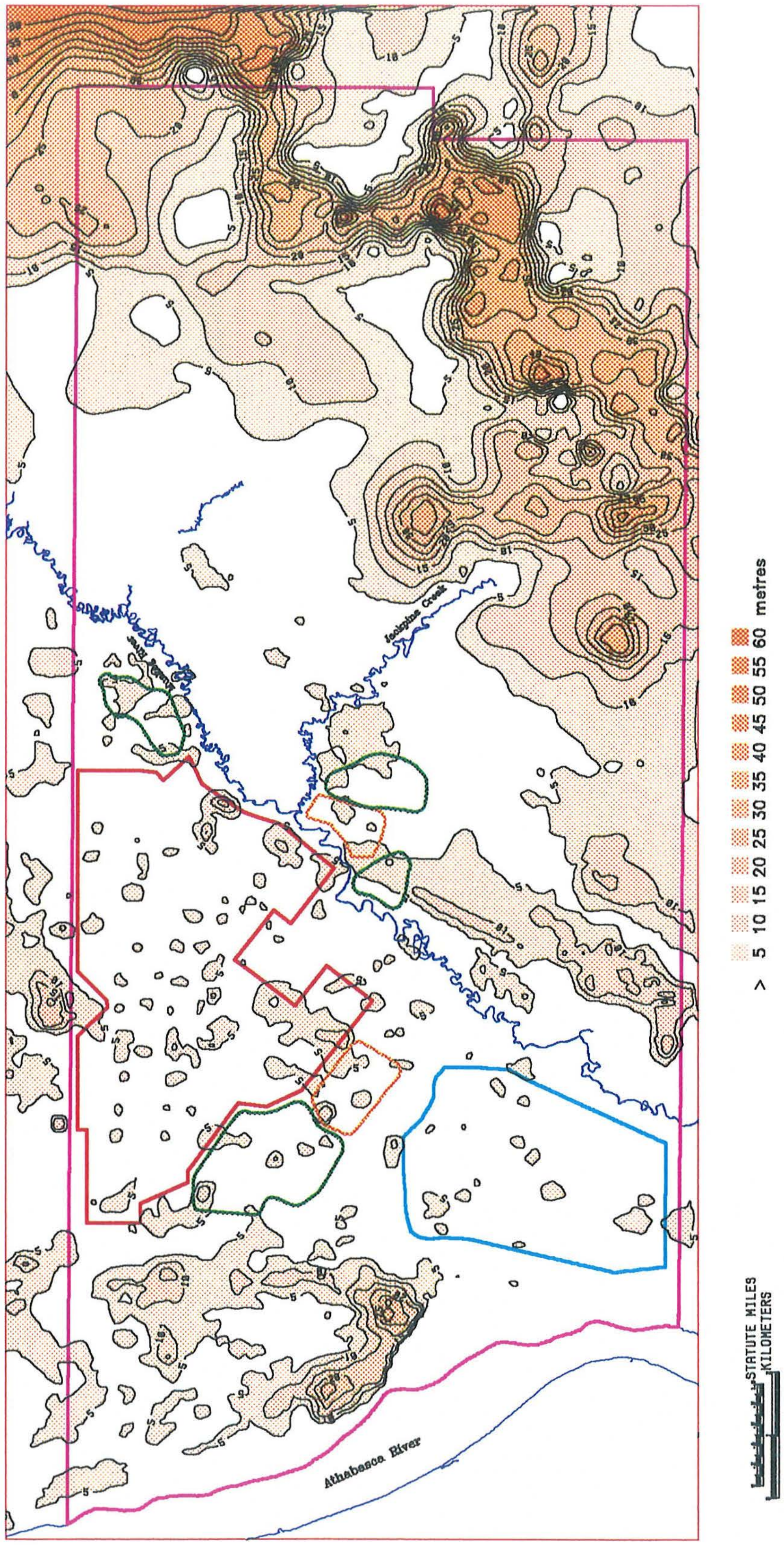


Figure 2-17: Isopach of Post-McMurray Deposits

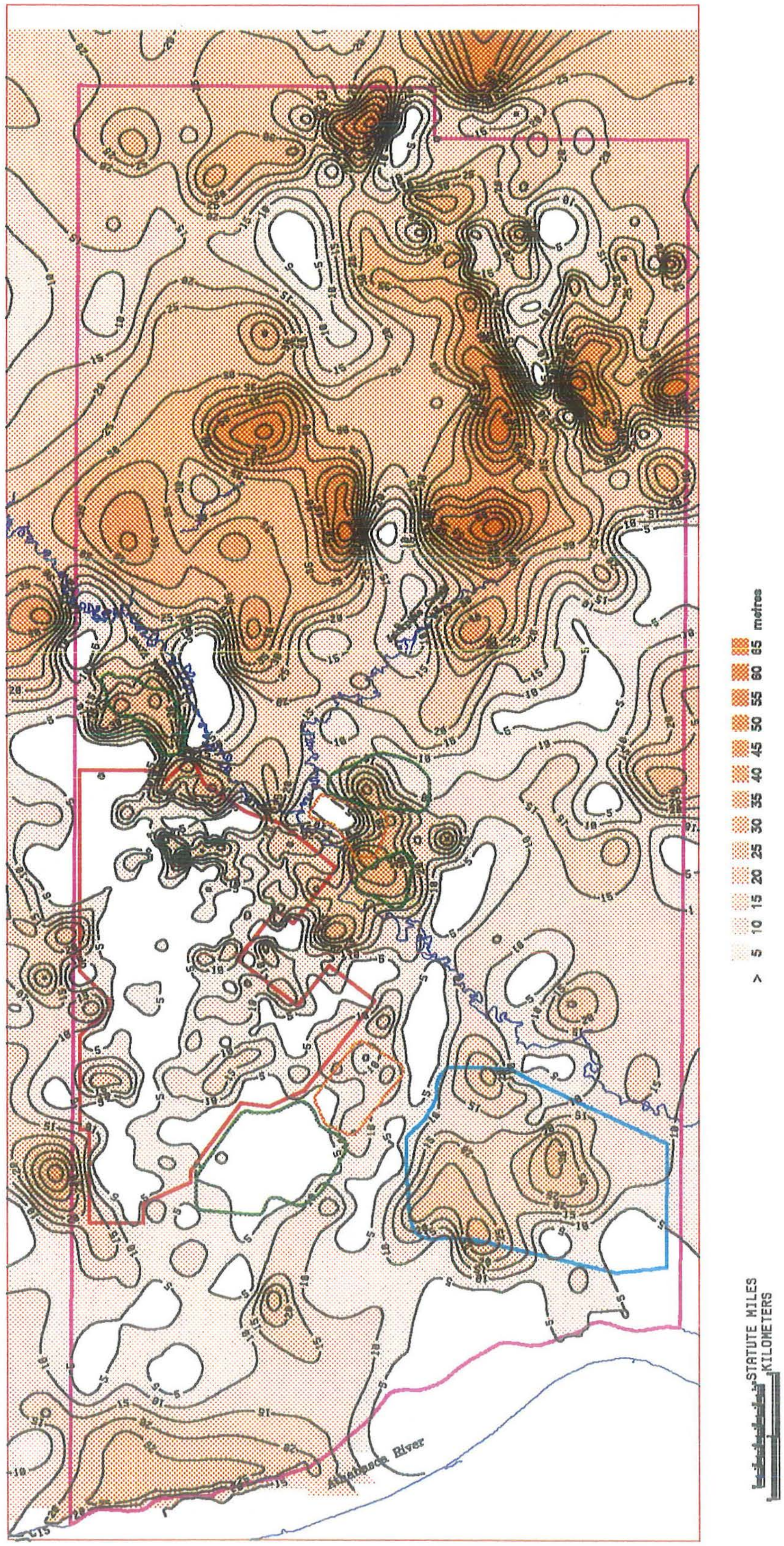


Figure 2-18: Isopach of Centre Reject

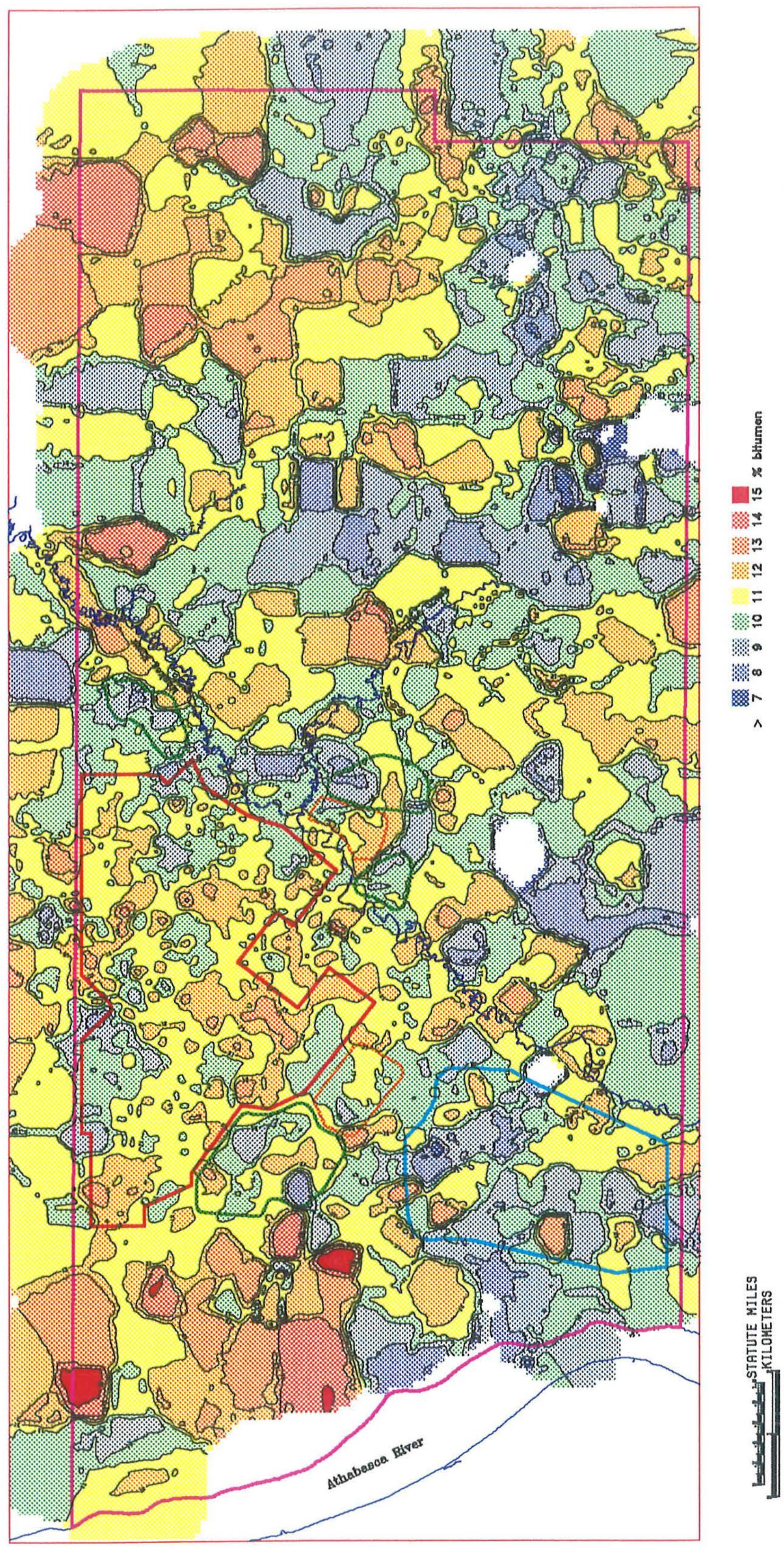


Figure 2-19: Average Ore Grade

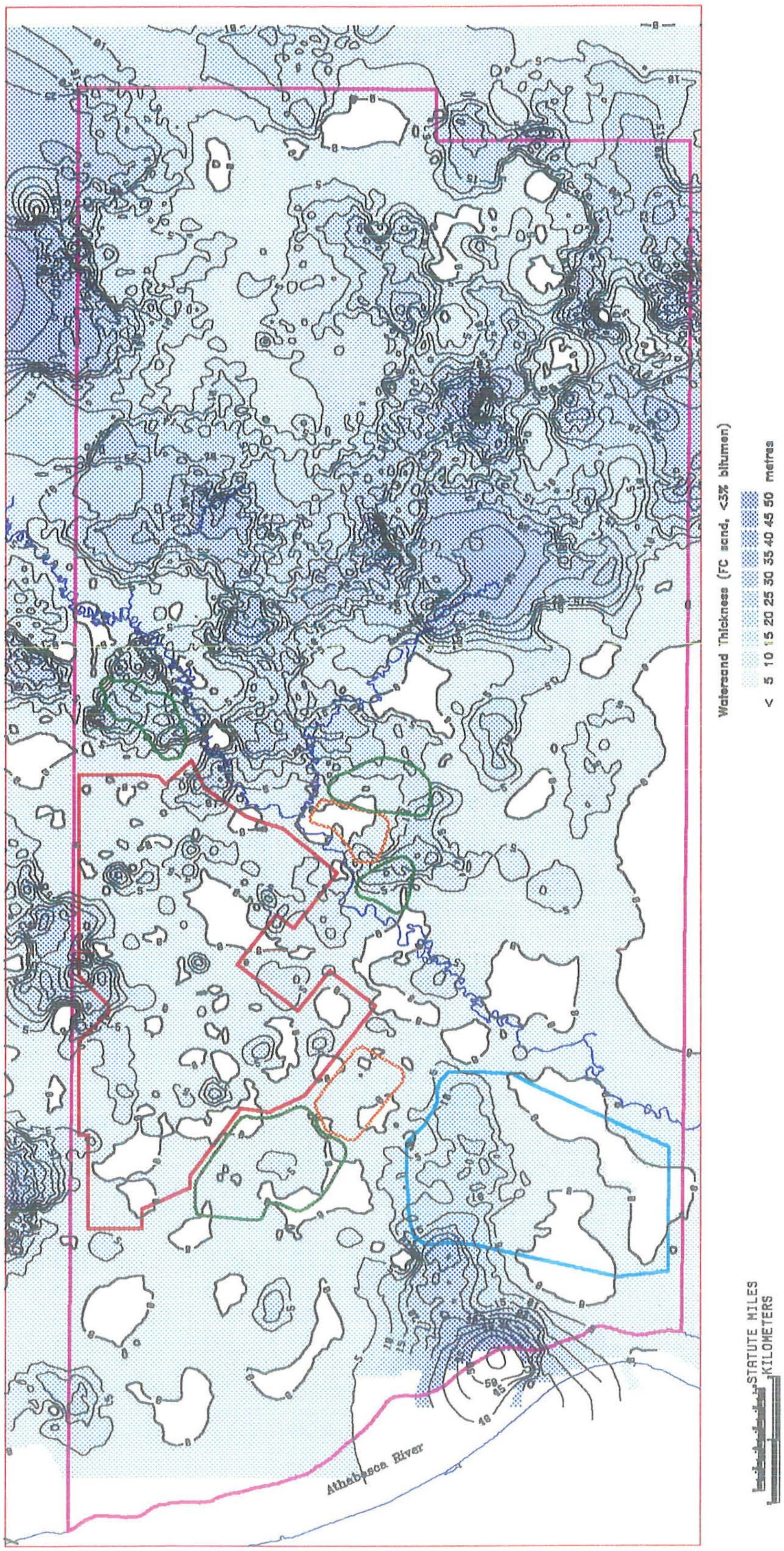


Figure 2-20: Isopach of Basal Aquifer

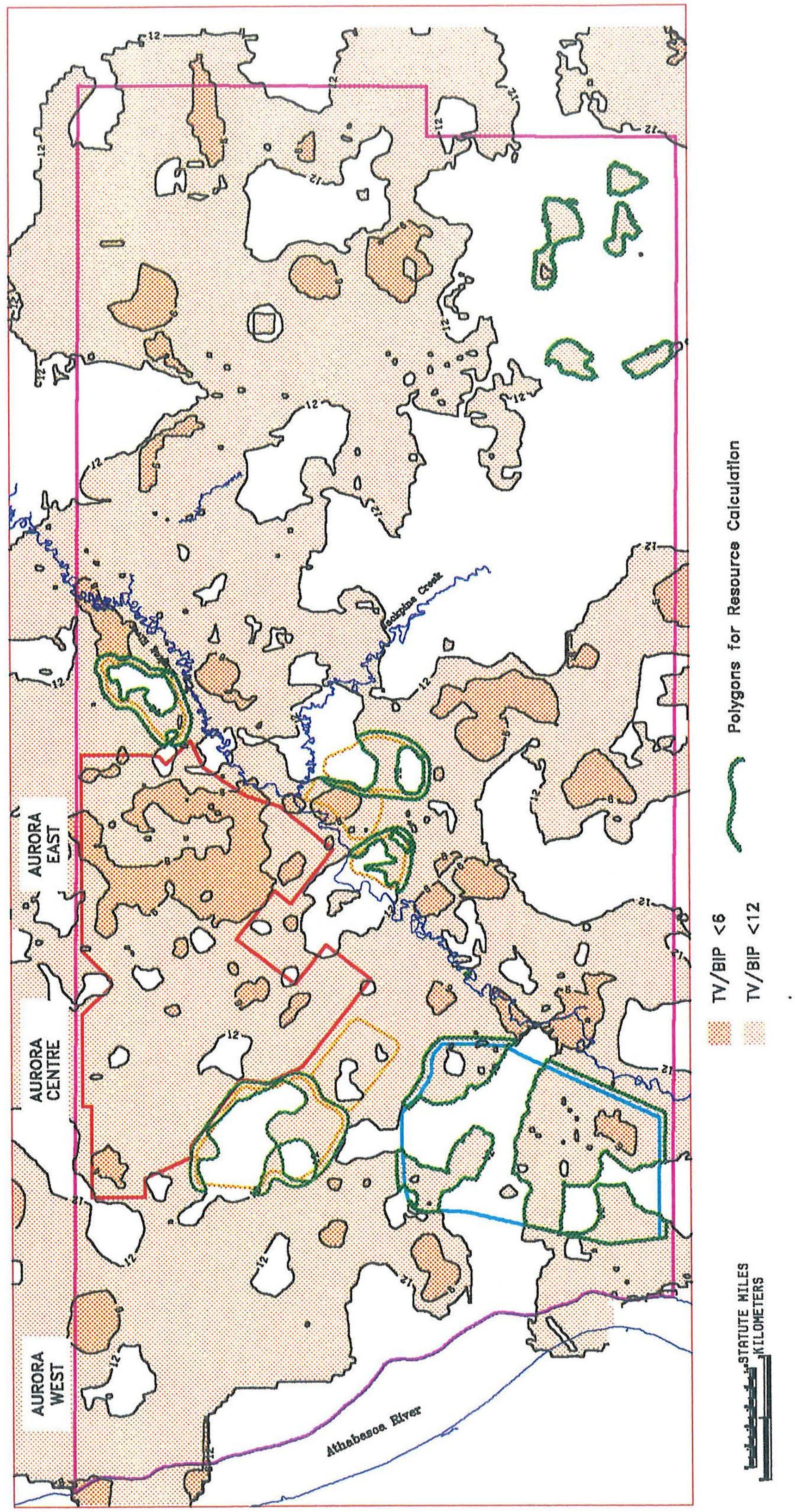


Figure 2-21: Resource Estimate Plan

MINE PLAN

PURPOSE

The 1998 winter exploration provided additional information for the geological interpretation of the Muskeg River Mine orebody. The overall integrity of the mine plan remains unchanged, including the:

- mining sequence
- mining reserves
- economic pit limits
- geotechnical considerations
- mining method

The only modification to the mining plan is minor changes to the disposal areas.

WEST DISPOSAL AREA

The geological interpretation in the west disposal area is consistent with the application (see Disposal Areas in Section 2.4), so no change to the surface area, elevation or volume of the west disposal area is required.

NORTHEAST AND SOUTH DISPOSAL AREAS

Mine planning requires about 66 million m^3 of overburden and centre reject material to be hauled to the south and northeast disposal areas in the early years of mining operations.

The south disposal area is preferred for early development because its use reduces:

- haul distances
- mining costs
- resource sterilization

The updated geological model, which incorporates the 1998 drilling results, shows that some potentially economic ore would be sterilized by the original design of these disposal areas. Therefore, the south disposal area has been truncated to avoid as much potentially economic material as possible. To compensate for the area lost, a second small disposal area has been defined, west of the original site.

NORTHEAST AND SOUTH DISPOSAL AREAS (cont'd)

The northeast disposal area has been realigned to conform to the area of poorest resource potential, and slightly increased in size to accommodate the excess material affected by the modified south disposal area.

PROPOSED MODIFICATIONS

Shell proposes to modify the northeast and south disposal areas slightly to minimize the impact on resource sterilization (see Figure 3-1). The changes are summarized in Table 3-1.

The minor changes made to the disposal areas have been designed to maintain the integrity of the:

- mine mass balance
- total area disturbed
- closure and reclamation plan

The reclamation material stockpile has also been altered to allow for a safe and efficient road layout. The south and northeast disposal areas will have a minimal impact on the overall reclamation and mine plan.

Table 3-1: Proposed Changes to Northeast and South Disposal Areas

Disposal Site	Total Area (ha)		Volume (Mm^3)	
	Application	Update	Application	Update
South (main)	174	110	53	33
South (small)	-	53	-	13
Northeast	81	92	13	20
Total	255	255	66	66

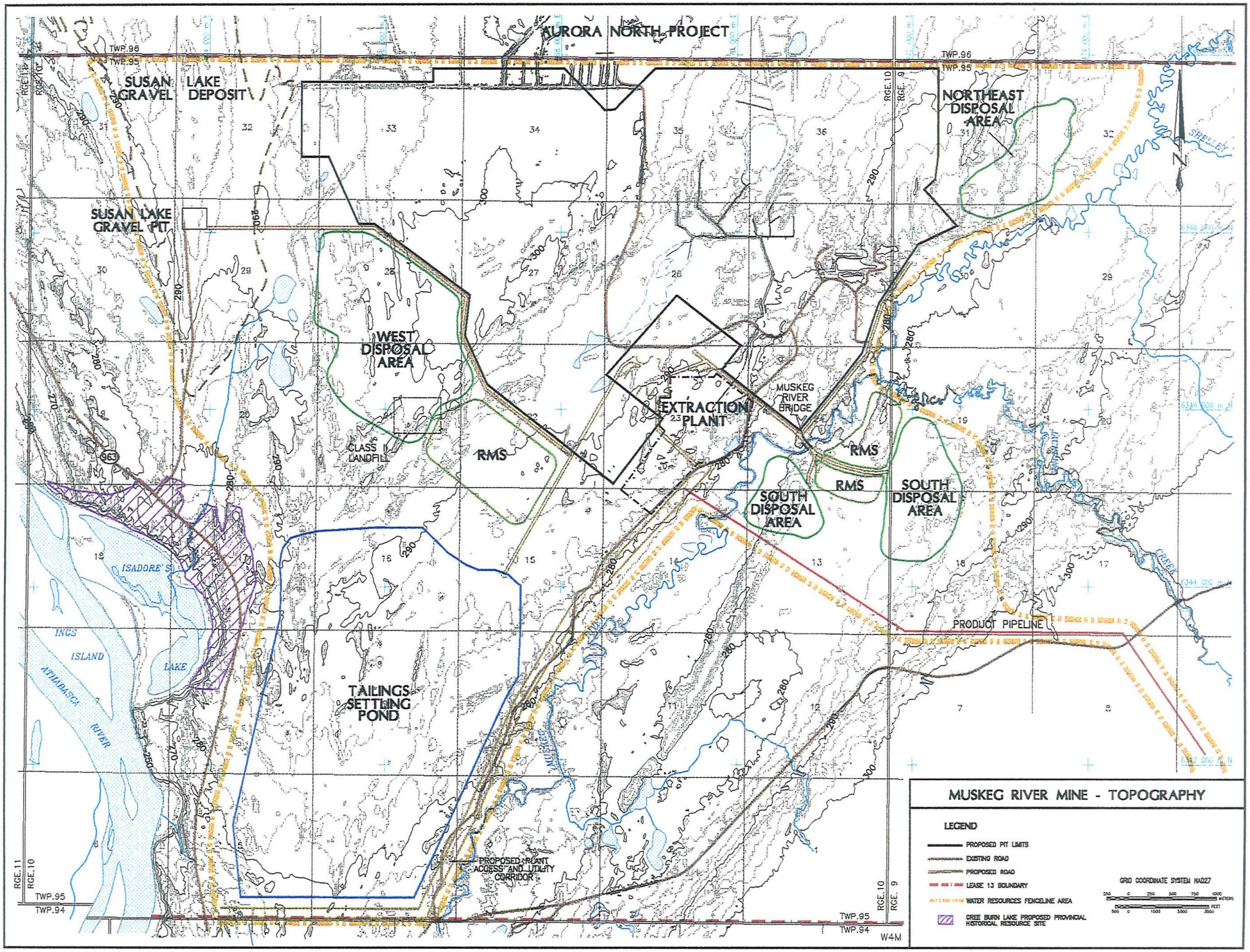


Figure 3-1: Lease 13 Topography

Shell Canada Limited

PURPOSE

The development of a new oil sands mining project requires the placement of necessary surface facilities, such as the tailings settling pond and the disposal areas, which will inevitably sterilize some areas of potentially economic ore.

These facilities will be located with the objectives of minimizing:

- the environmental impact
- the amount of potentially economic ore sterilized
- the cost

Shell's mining plans for the Muskeg River Mine provide a reasonable balance of each of these competing objectives.

Resource estimates for the Muskeg River Mine and areas influenced by surface facilities and features are provided in Table 3-2.

RESOURCE LIMITS

Contours of optimized TV/BIP = 12 were developed from the geological model, and formed the basis of a reasonable outline for resource estimates. No attempt was made to develop mining plans for potential pits within the contoured limits.

GEOTECHNICAL SETBACKS

The setback distance from a disposal area is site specific and requires a detailed geotechnical analysis at each particular location. An assessment for each site would include:

- physical and geotechnical condition of the material in the disposal area
- preparation of the surface before deposition
- geotechnical conditions of the subsurface strata
- hydrogeological conditions
- conditions of any potential advancing mine face

This update is not intended to provide a geotechnical assessment of potential mining faces near the Muskeg River Mine's disposal areas. For the purpose of estimating the resource impacted by disposal areas, a setback range of up to 100 m has been assumed (see Figure 3-2).

SURFACE FEATURES AND FACILITIES

Corridors

The Muskeg River Mine is serviced by the main access corridor and the bitumen product pipeline corridor. The corridors will not sterilize the resources, as they could be relocated to access the resource in the future.

Table 3-2: Resource Estimates

Resource Estimates	Ore	Overburden and Centre Reject Mbcm	Waste to Ore Ratio bcm/t	Average Grade %	In Situ Bitumen Mbbl	Average TV/BIP bcm/m^3	Recoverable Bitumen Mbbl	Average TV/NRB bcm/bbl
Disposal Sites[1]								
Northeast	16.1	9.0	0.56	10.6	10.6	10.0	9.0	1.9
South	23.4	12.3	0.53	11.7	17.1	8.7	15.0	1.6
South (small)	13.4	8.9	0.66	10.5	8.8	11.1	7.5	2.1
West	57.6	43.8	0.76	11.7	42.2	10.7	37.1	1.9
Tailings Pond 1	247.8	116.0	0.47	11.3	174.4	8.5	151.8	1.5
Tailings Pond 2	88.2	51.6	0.59	11.2	61.5	9.7	53.4	1.8
Disposal Sites[2]								
Northeast	49.3	21.9	0.44	10.6	32.6	8.9	27.7	1.6
South	43.4	21.6	0.50	11.3	30.6	8.8	26.6	1.6
South (small)	23.9	15.5	0.65	10.7	15.9	10.7	13.6	2.0
West	104.1	77.5	0.74	11.6	75.6	10.7	66.2	1.9
Tailings Pond 1	296.7	140.7	0.47	11.1	206.2	8.6	178.5	1.6
Tailings Pond 2	88.2	51.6	0.59	11.2	61.5	9.7	53.4	1.8
RMS[3]								
West	62.0	33.3	0.54	11.0	42.7	9.3	36.9	1.7
East	62.2	17.2	0.28	11.4	44.2	6.7	38.6	1.2
Lease 13[4]								
Lease 13 (<12TV/BIP)	9,853.1	4,198.6	0.43	11.5	7,085.6	7.9	6,196.5	1.4
Mine Area[5]								
Mine Area	1,726.1	528.7	0.31	11.4	1,229.5	7.0	1,072.8	1.3
Muskeg River[6]								
Wedge (approximate)	41.6	1.8	0.04	11.0	28.6	4.7	24.7	0.9
Crusher Area[7]								
Ore beneath Crusher Elevation	3.5	1.7	0.48	9.6	2.1	10.0	1.7	2.0

Notes:
1. Disposal Sites – no setback, at TV/BIP<12
2. Disposal Sites – 100 m setback from toe, at TV/BIP<12
3. RMS (Reclamation Material Stockpile) – no setback, at TV/BIP<12
4. Lease 13 – at TV/BIP<12
5. Mine Area – all resource within the pit boundary
6. Muskeg River – all resource for 3 km length along the west edge of the mine
7. Crusher Area – all resource below the top of the centre reject, within the toe of the excavation

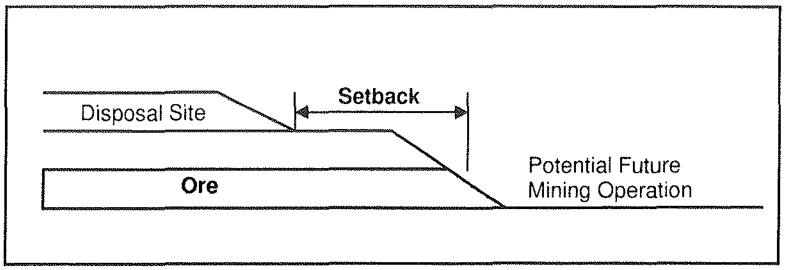


Figure 3-2: Representative Cross-Section of Geotechnical Setback

Disposal Areas

There are several surface features to the west of the tailings settling pond and the west disposal area. These include:

- the Syncrude Aurora access and utility corridor
- Highway 963
- a lodge for industrial workers
- the Cree Burn Lake proposed historical resource site

Reclamation Material Stockpiles

Reclamation material stockpiles will be removed as reclamation progresses. Therefore, they will not sterilize the resource.

Crusher

The crusher has been located in an area of thick, sandy, centre reject material, where the lower fluvial channel ore is thin and poor grade. Ore from the upper zones will be recovered and stockpiled during the excavation of the initial opening, and later processed through the plant when operations are underway.

Representative drill holes in the vicinity of the crusher location are shown in Figure 3-3.

At this stage of mine planning, the high strip ratio and low grade of the fluvial ore beneath the crusher do not warrant over-excavating and stockpiling.

Further optimization of the location and crusher elevation will be included in ongoing detailed mine planning, including the following factors:

- recovery of economic ore
- the cost of truck haulage
- conveyor lifting costs
- geotechnical stability of opening cut walls and crusher foundations

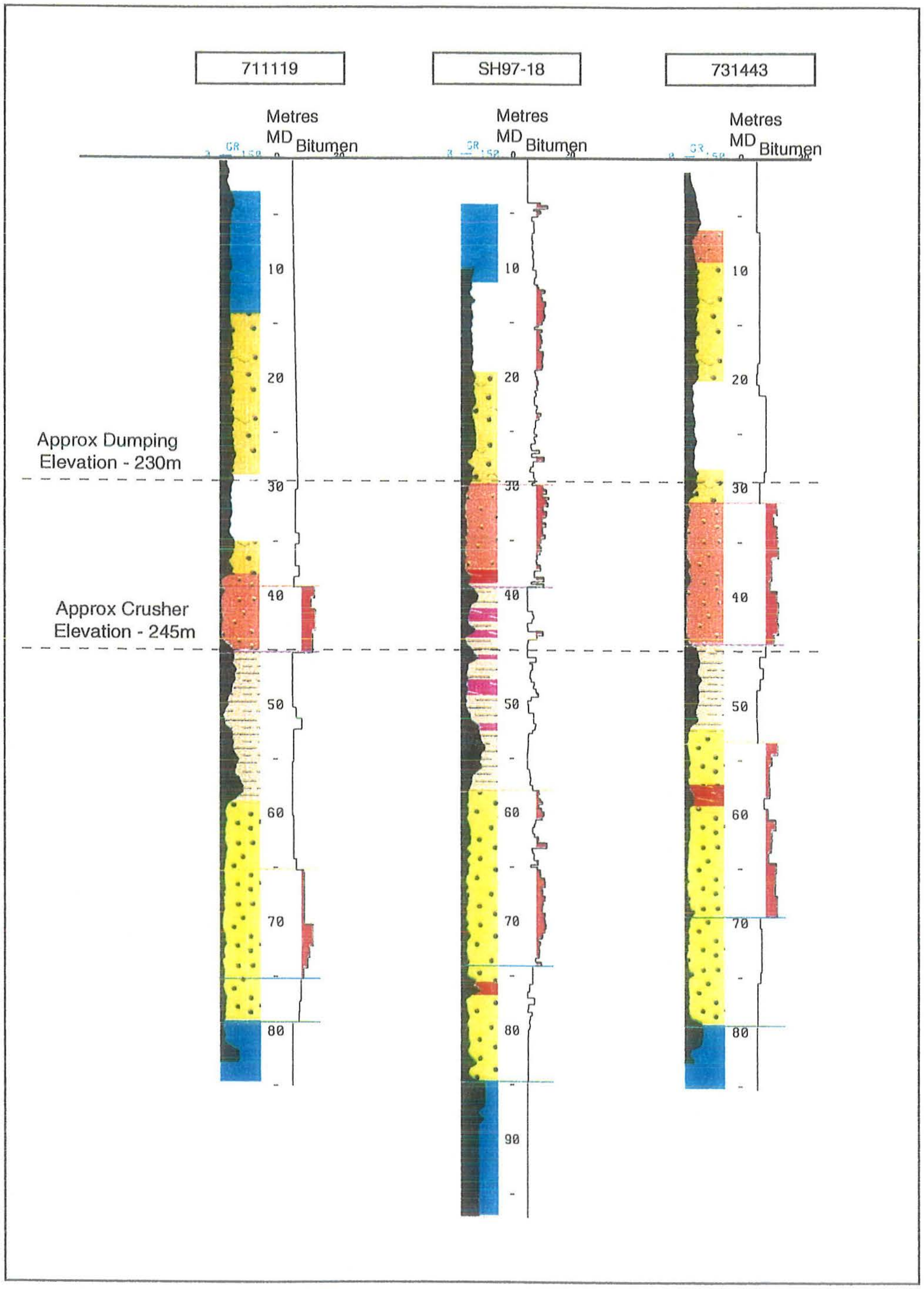


Figure 3-3: Representative Drill Holes Near Crusher Location

POTENTIAL SITES

Two potential sites for external tailings storage were evaluated in the application for approval:

- Tailings 1 on the southwest portion of Lease 13
- Tailings 2 on the southeast portion of Lease 13

The selection of Tailings Area 1 in preference to Tailings Area 2 in the application was based on a review of cost, geotechnical and environmental considerations. Although the preliminary estimate has since been revised, Tailings Area 1 still remains the preferred option.

ECONOMIC ANALYSIS

A preliminary economic analysis of alternative tailings locations was performed before detailed mine planning. Typical unit cost estimates were applied to various options for plant site, tailings location and mining sequence, and then compared to the selected option on a net present value (NPV) basis.

A recent review of the analysis revealed that the preliminary estimate was inaccurate. This estimate has been revised and shows that Tailings Area 1 has a $300 million advantage (on an NPV basis) over Tailings Area 2.

Capital Cost Difference

The differences in capital costs (29% of total) include:

- additional road construction and starter dyke costs
- creek diversions and crossings (e.g., Jackpine Creek)
- additional pumps, lines, booster stations and power lines

Operating Cost Difference

The differences in operating costs (66% of total) include:

- additional tailings pumping costs over increased distance and elevation (30 m in topography change)

- additional water recycle distance

Operating Cost Difference (cont'd)

- thin fine tails (TFT) and mature fine tails (MFT) pumping costs for the duration of consolidation tailings deposition

- additional general operating expenses (road maintenance, equipment transfers)

Reclamation Cost Difference

The differences in reclamation costs (5% of total) include:

- returning cell capping sand over increased distance
- additional distance for pumping water and TFT to the end-pit lake
- additional haulage for reclamation material

PURPOSE

Shell has been developing a Lease Boundary Agreement framework to address harmonization and management of lease boundaries. The objectives are to:

- maximize the recovery of economic ore at the boundary
- equalize economic costs and benefits between the parties
- conduct a situation analysis to establish the best economic solution

Discussions have taken place with Syncrude with the goal of developing guidelines that could be broadly applied to the surface mining oil sands industry to address recovery of economic resource at lease boundaries. The desire has also been to involve the EUB staff in ongoing and timely reviews to ensure their input is captured in the development of the lease boundary harmonization agreement framework.

The result of this work will be provided to other industry participants.

MUSKEG RIVER MINE AND AURORA NORTH BOUNDARY

Given the proximity, both in physical location and timing of their respective developments, Shell and Syncrude have engaged in a specific study related to lease boundary management between the Muskeg River and Aurora North mines.

The study includes:

- defining and integrating the mine development plans
- analyzing options for lease boundary management
- recommending the best option

Mine Development Plan Definition and Integration

The initial stage of evaluation will include sharing geologic and mine planning information to form a common basis for the evaluation of lease boundary alternatives, including:

- sharing geological information and identifying common boundary areas containing potential ore based on TV/BIP <12

- preparing a resource development schedule for each company on their respective mines adjacent to each of the boundary areas

Mine Development Plan Definition and Integration (cont'd)

- developing a materials balance schedule to include initial development, mining, in-pit construction and materials storage

Option Analysis for Lease Boundary Management

The second stage will evaluate alternatives with a common set of mine plans and a database of evaluation criteria and unit costs, by:

- assessing NPV-based calculations for comparative analysis on the basis of the following four full cycle alternative cases:
  - Case A — separate mining and dyke construction at the boundary
  - Case B — agreement to overstrip or understrip, with the construction of a common dyke along or adjacent to the boundary
  - Case C — separate mining to the boundary, retaining a minimum in situ oil sand wedge as the core for separately constructed dykes
  - Case D — separate mining to the boundary, retaining a maximum in situ oil sand wedge as the dyke
- including the other issues that will not be reflected in the NPV evaluation, such as operational and environmental liability implications, and royalty implications

Figure 3-4 shows conceptual cross-sections of the proposed study cases.

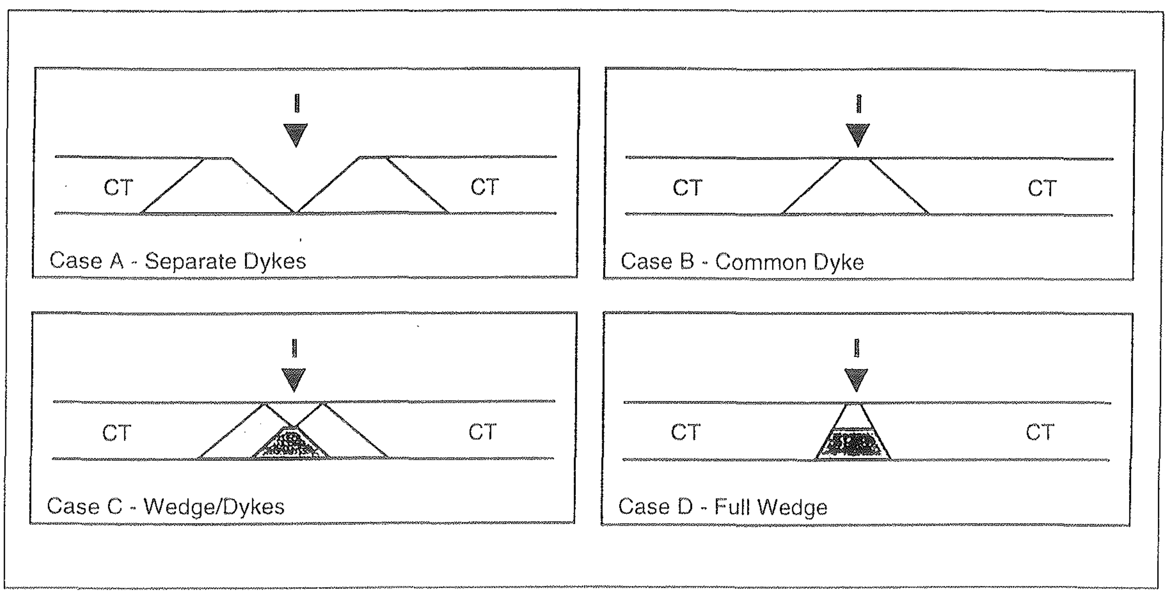


Figure 3-4: Conceptual Cross-Sections of Proposed Study Cases

Recommendation of Optimum Alternative

The outcome of the study will be used to:

- define the optimum recommended alternative on the basis of current information
- recognize the potential for change to each party's planning basis, and define which circumstances might be significant enough to warrant revisiting the boundary agreement

MANAGEMENT SCHEDULE

EUB Participation

The proposal is to use a working team approach with EUB involvement to:

- establish the study process
- define key interests and issues

It is also proposed to have ongoing, monthly reviews with defined EUB staff.

The intent is to take the learnings from this specific review of Shell's Muskeg River Mine and Syncrude's Aurora North Mine lease boundary options, then revisit the more generic Lease Boundary Agreement to finalize a standard agreement that industry and regulators can adopt and follow.

Proposed Timetable

The proposed process schedule (see Table 3-3) is designed to allow adequate time for EUB involvement.

Table 3-3: Process Schedule

Date	Action
Early June 1998	• Agree on framework • Discuss process with EUB
June 1998	• Share relevant geological information for a common database • Agree on geology and areas of common mining
July and August 1998	• Combine mining plans • Establish database of evaluation criteria and unit costs • Work through case studies • Review interim report — Shell–Syncrude–EUB
September 1998	• Identify and resolve issues • Apply sensitivity study • Agree and select best option • Prepare and present final report — Shell–Syncrude–EUB

INTERFACE WITH KEARL OIL SANDS MINE

Subsequent to the submission of the Muskeg River Mine application, Shell has had discussions with some key stakeholders to clarify its intent regarding the scope of project area contemplated for regulatory approval. In particular, Mobil has expressed uncertainty about the extent of the project area and the potential implications and interface with its Kearl Lake Oil Sands Mine.

The extent of the Muskeg River Mine Project area was shown previously in Figure 3-1 (see Section 3.1). The outlined project area also coincides with the fenceline area for approvals under the *Water Resources Act* (see Section 6.1). Shell emphasizes that the application for approval submitted to the EUB in December 1997 is only for developing a mining area to the west of the Muskeg River Mine. Any approvals for mining on the eastern part of the lease, particularly in the proximity of Mobil's Kearl Oil Sands Mine, would be the subject of a future application and approval process.

PURPOSE

A road crossing of the Muskeg River is proposed to enable overburden and reclamation materials to be hauled to the south disposal area. The crossing is designed to initially accommodate a single lane of traffic consisting of waste rock haul trucks with gross vehicle weights of up to 550 t. Preliminary engineering has been completed in order to identify a reliable, cost effective, functional and environmentally acceptable crossing design. Several crossing options were evaluated. The selected option is a three-span girder bridge, which has been designed to avoid any harmful alteration, disruption or destruction of fish habitat.

CROSSING SITE

The crossing location is based on surveyed cross-sections, aerial photos, and site observations and addresses several potential issues associated with this particular crossing, including:

- selecting a crossing that minimizes haulage distances between the south storage sites and the planned sources of material
- assessing local topographical characteristics of the river basin to locate a confined river channel that allows a short crossing and minimizes the potential for environmental disturbance
- identifying and avoiding areas of important fish habitat

The proposed crossing location is situated where the main river channel is narrow (about 10 m) and appears to be relatively stable. Also, the natural terrain is relatively high at the proposed crossing location. This minimizes the requirements for approach roadway embankment construction. These site characteristics are considered desirable for the crossing because, in comparison to adjacent sites along the river, they would result in the:

- least amount of environmental disturbance
- least costly structure

The siting criteria included:

- minimizing the effects to high quality run and riffle (during low flow) habitats identified in the area of the crossing

CROSSING SITE (cont'd)

- the design of the crossing structure

Figure 3-5 shows the preferred location at the relatively narrow, stable area of the stream. This location has the least potential to affect high quality spawning habitat, as riffle sites have been avoided. The design of the crossing structure addresses the hydraulic integrity of the riverbed downstream.

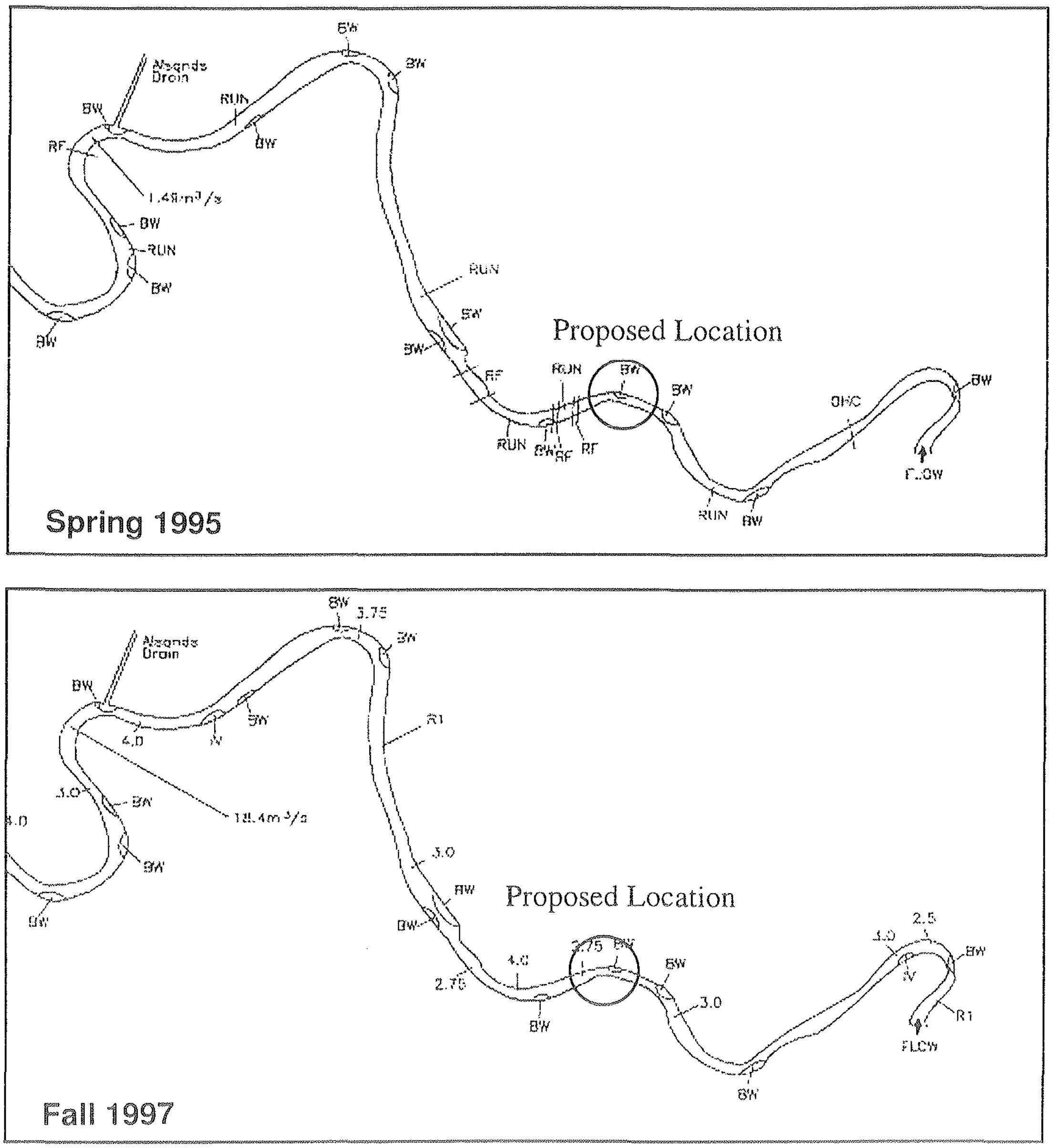


Figure 3-5: Muskeg River Crossing Preferred Location

DESIGN

The following criteria were incorporated when the design of the crossing was evaluated:

- potential environmental impacts of each type of structure to the Muskeg River
- potential effects to wildlife migration along the Muskeg River
- hydrology of the river system and any anticipated impacts on the river channel as a result of each design option
- regulatory requirements of the DFO and the Canadian Coast Guard
- bridge roadway width compliance with appropriate mine safety standards
- cost of the structure

Options Considered

Three options were considered for this crossing, based on site characteristics and other similar crossings that have been built in the Province of Alberta:

- a single-span girder bridge (30 m)
- a culvert installation
- a three-span girder bridge (9 m - 12 m - 9 m)

The single-span girder option is feasible, but will cost significantly more than the three-span option because of the:

- significantly larger superstructure span
- large design vehicle loading criteria

The single-span and three-span designs at this particular crossing both have similar minimal environmental effects.

The culvert option is well suited for carrying the heavy loads associated with the specified design vehicle. However, this option has a greater construction risk, and the associated environmental impacts of instream construction make it less desirable. Therefore, the culvert option has been dropped from further consideration.

Selected Option

The three-span girder option is being proposed for the Muskeg River crossing. It is a common bridge configuration used throughout Alberta in locations where small river crossings have been built. A bridge plan is shown in Figure 3-6 and an elevation is presented in Figure 3-7. A photograph of the proposed location is shown in Figure 3-8.

Selected Option (cont'd)

Particular features of this crossing include:

- a 12 m centre span, which effectively crosses the river channel without the need for in-stream construction activity
- a 2 m vertical clearance above the average high water line, to comply with *Navigable Waters Protection Act* (NWPA) requirements
- a roadway width twice that of the design vehicle, which gives a single-lane width of about 17 m
- abutments on each shore of the river designed to include a wildlife corridor on either side of the river, effectively mitigating the impact of the crossing to migrating wildlife. The corridor has a 3 m clearance to allow passage of an adult moose.

The contractors that will build the bridge are familiar with the three-span girder style of bridge. The expected environmental effects are predictable.

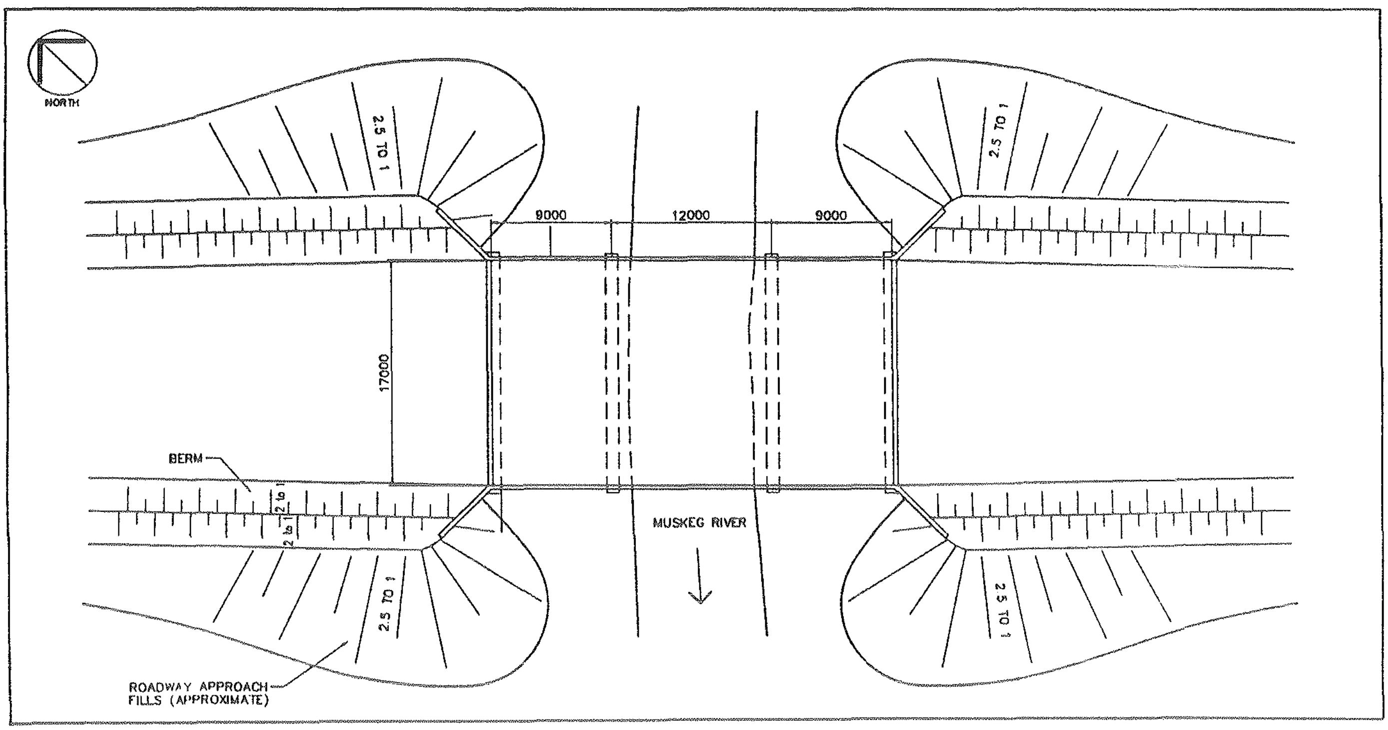


Figure 3-6: Muskeg River Crossing Bridge Plan

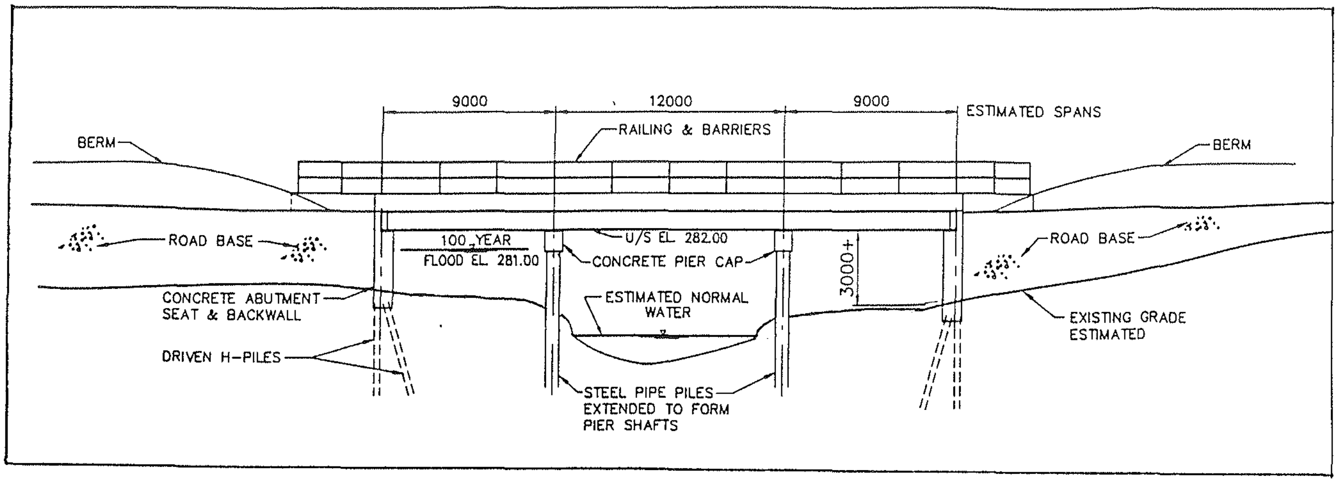


Figure 3-7: Muskeg River Crossing Bridge Elevation

Superstructure Alternatives

The three superstructure alternatives being considered are:

- a cast-in-place concrete deck of girder solid slab
- steel girders with a cast-in-place concrete deck
- precast concrete girders with a cast-in-place concrete deck topping

Abutments and piers for the proposed superstructure alternatives will be similar in design. The abutment seat will likely be founded on driven steel pipe piles cast integrally to the girder ends, effectively eliminating the need for moving bearings. This type of integral abutment has been used successfully throughout western Canada for traffic bridges up to 50 m long and for rail bridges up to 100 m long. The pier shafts will be extended up to directly support the superstructure. A concrete pier (pile) cap will provide a continuous bearing surface for the steel and precast concrete girders. The pier cap will not be required for the cast-in-place deck and girder option as the solid deck slab would be founded directly on top of the piers.

Design Code

The proposed bridge will be built to meet the national standard CAN/CSA-S6-88 *Design of Highway Bridges*, which governs the design of highway bridge structures constructed in Alberta.

Geotechnical and Hydrological Considerations

A preliminary geotechnical and hydrological review of the site was conducted. The key findings are that:

- Steel piling driven into the underlying McMurray Formation is a practical foundation for the proposed bridge. Shallow-footing-type foundations are unsuitable for supporting the proposed bridge.

Geotechnical and Hydrological Considerations (cont'd)

- The three-span bridge structure offers minimal interference to river flows in the main channel. During the detailed design phase, particular attention will be paid to scour and erosion protection measures for flood events near the approach road embankments.

- The 10-year and 100-year flood levels at the site, without considering any channel constriction resulting from the bridge crossing, are estimated to occur at elevations of 280.1 m (10-year) and 281 m (100-year). Currently, the 281 m (100-year) flood elevation has been assumed to be applicable for the purpose of establishing bridge structure proportions. In consideration of this elevation and recommendations published in the *Guidelines for Bridge Structures Standards, Approvals and Design,* Alberta Transportation and Utilities, 1994, the underside of the bridge superstructure has been set at 282 m for this study.

CONSTRUCTION

Construction methods of the selected crossing option are designed to minimize environmental impacts, the most critical of which are:

- direct impacts to the river bed in the immediate crossing location

- impacts to the river bed and water quality downstream from sediment introduced into the river during construction

- direct or indirect impacts to spawning fish: from April 20 to July 1 (Arctic grayling) and from April 15 to July 15 (northern pike)

Construction of the proposed three-span bridge will be uncomplicated. The bridge can be constructed at virtually any time during the year, except during floods. To mitigate potential environmental impacts, work potentially affecting the river channel will be scheduled between August and March, to avoid key fish species spawning periods. Work scheduled for the river banks, such as pier installation and other earthworks will be scheduled for the winter, when sediment control measures are more effective. Construction activity, such as deck placement, will not cause river disturbance, and can proceed at any time during the year.

Erosion Control

Permanent and temporary erosion control measures will be taken to prevent introducing sediment into the river, regardless of the construction season. Such measures include:

- silt fences
- revegetation programs

Habitat Protection

Other specific actions taken for habitat protection will comply with fish habitat protection guidelines published by AEP, Fisheries Management Division and with those published by Alberta Transportation and Utilities.

Construction Duration

Excluding approach-fill placement, construction of the proposed crossing structure is expected to take from two to four months of continuous on-site time.

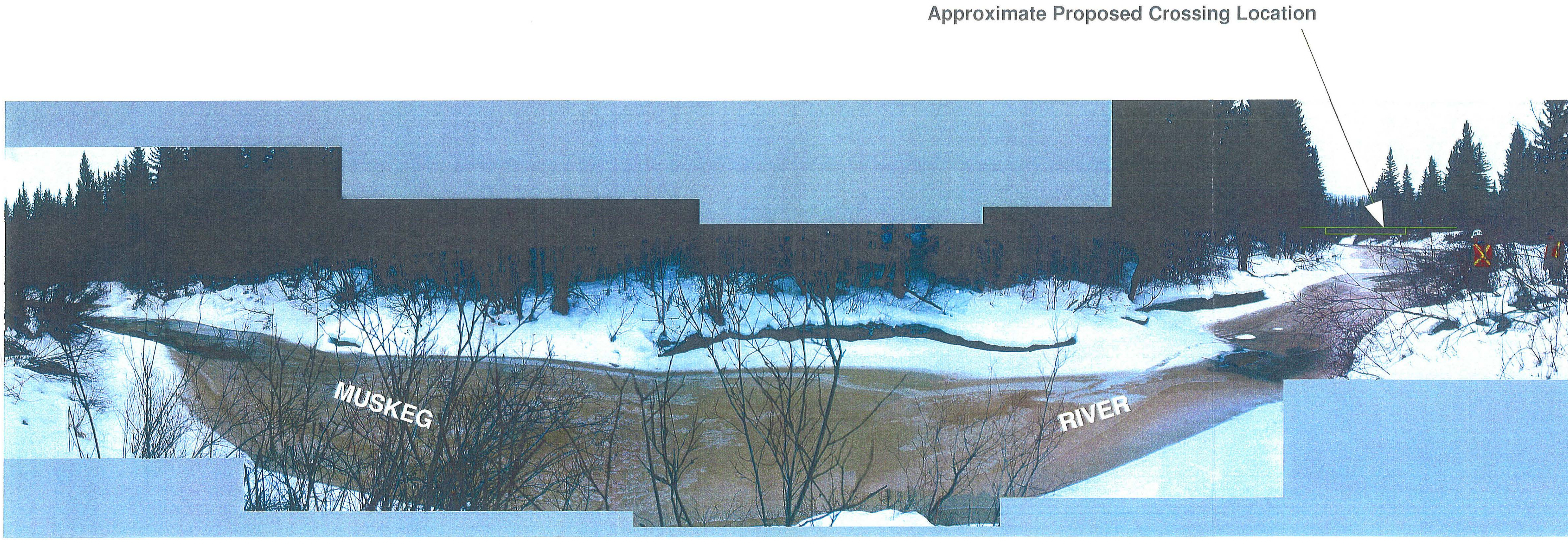


Figure 3-8: View of Muskeg River near Proposed Crossing Location

SCOPE

The mine development and reclamation progression plans presented in the application for approval have been updated. The updated plans are provided as follows:

- Figure 3-9 Composite Mine Plan
- Figure 3-10 Mine Development and Reclamation Progression Plan, Year Ending 1999
- Figure 3-11 Mine Development and Reclamation Progression Plan, Year Ending 2000
- Figure 3-12 Mine Development and Reclamation Progression Plan, Year Ending 2001
- Figure 3-13 Mine Development and Reclamation Progression Plan, Year Ending 2002
- Figure 3-14 Mine Development and Reclamation Progression Plan, Year Ending 2003
- Figure 3-15 Mine Development and Reclamation Progression Plan, Year Ending 2004
- Figure 3-16 Mine Development and Reclamation Progression Plan, Year Ending 2005
- Figure 3-17 Mine Development and Reclamation Progression Plan, Year Ending 2006
- Figure 3-18 Mine Development and Reclamation Progression Plan, Year Ending 2007
- Figure 3-19 Mine Development and Reclamation Progression Plan, Year Ending 2008
- Figure 3-20 Mine Development and Reclamation Progression Plan, Year Ending 2009

SCOPE (cont'd)

- Figure 3-21 Mine Development and Reclamation Progression Plan, Year Ending 2010
- Figure 3-22 Mine Development and Reclamation Progression Plan, Year Ending 2016
- Figure 3-23 Mine Development and Reclamation Progression Plan, Year Ending 2020
- Figure 3-24 Mine Development and Reclamation Progression Plan, Year Ending 2022

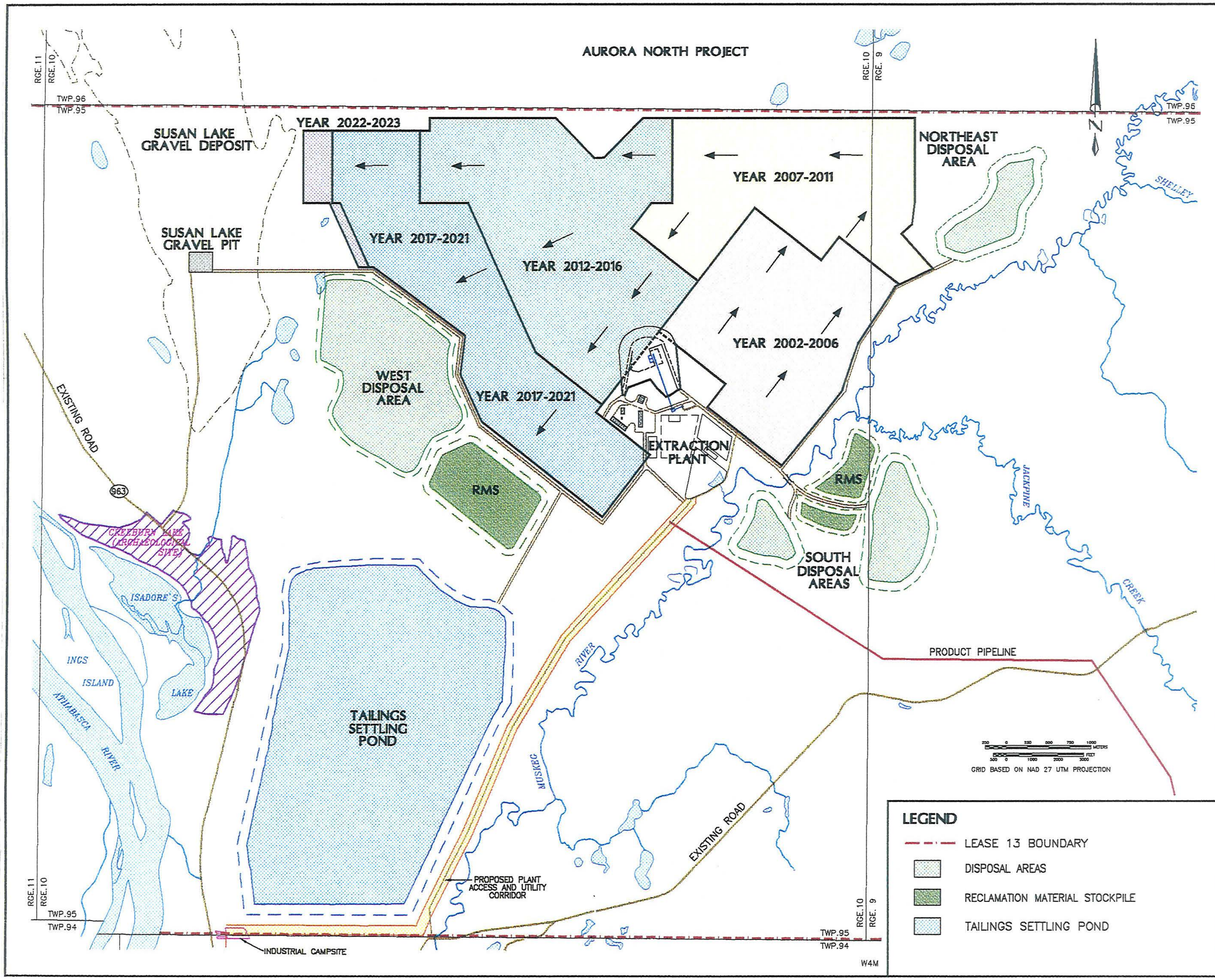


Figure 3-9: Composite Mine Plan

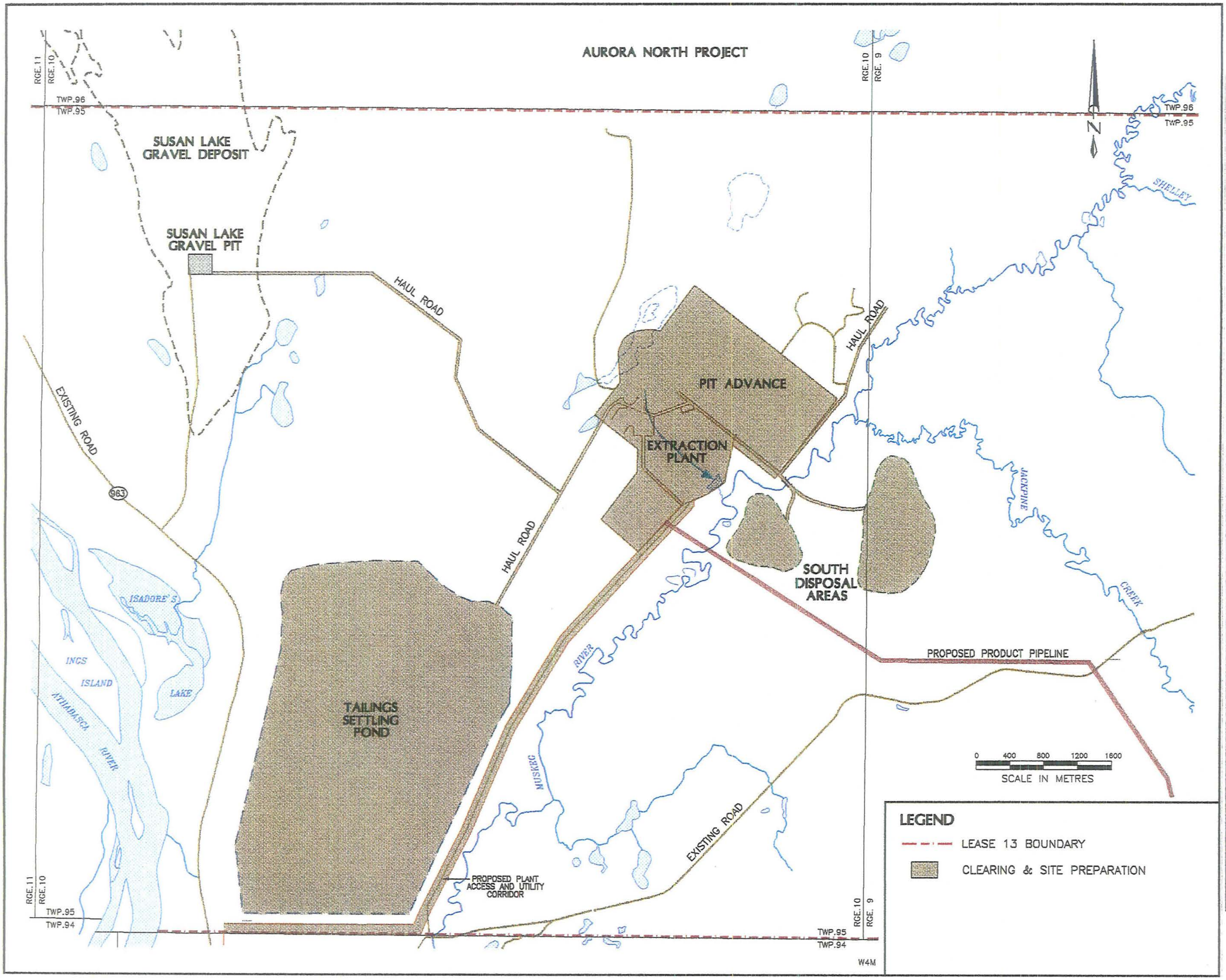


Figure 3-10: Mine Development and Reclamation Progression Plan, Year Ending 1999

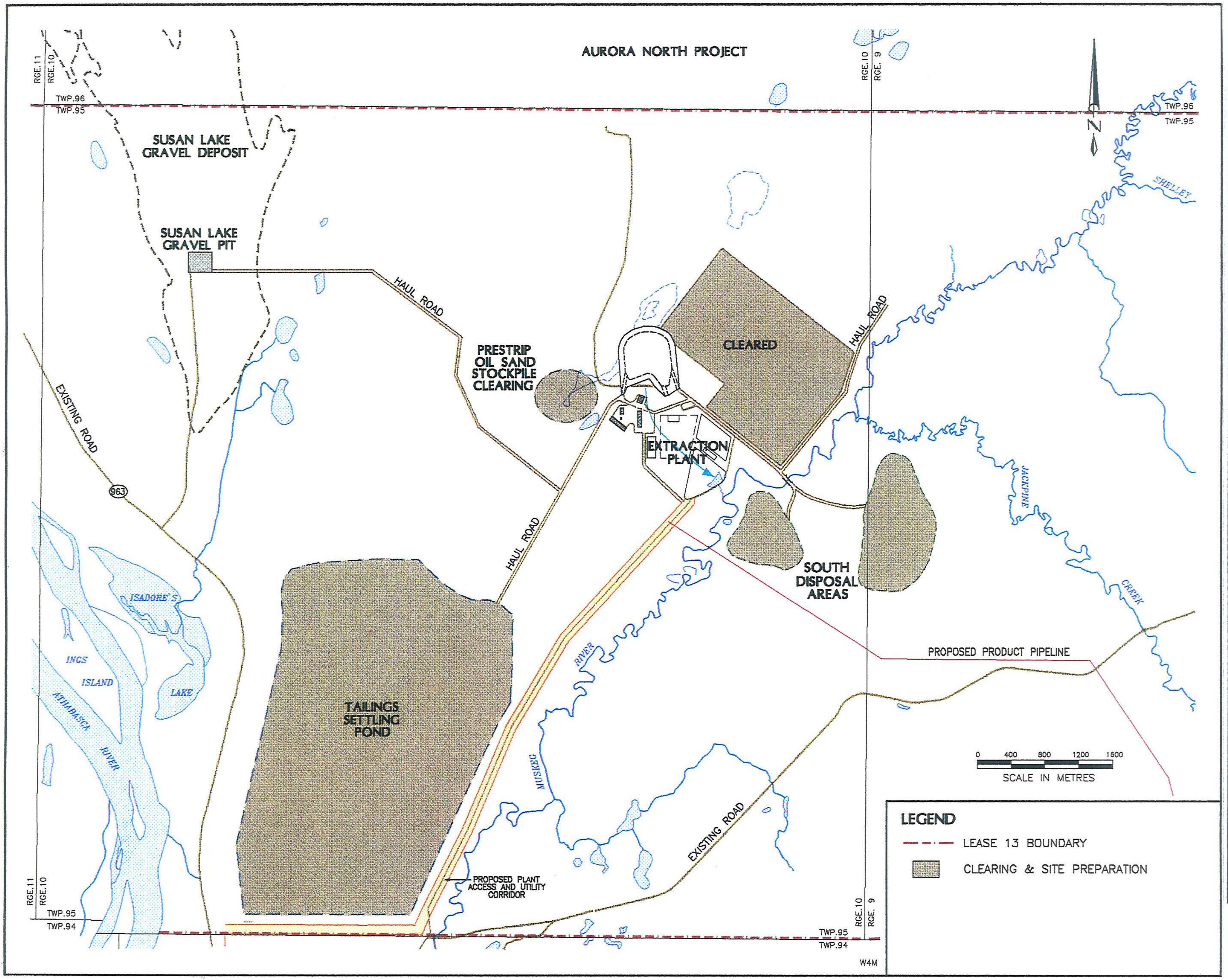


Figure 3-11: Mine Development and Reclamation Progression Plan, Year Ending 2000

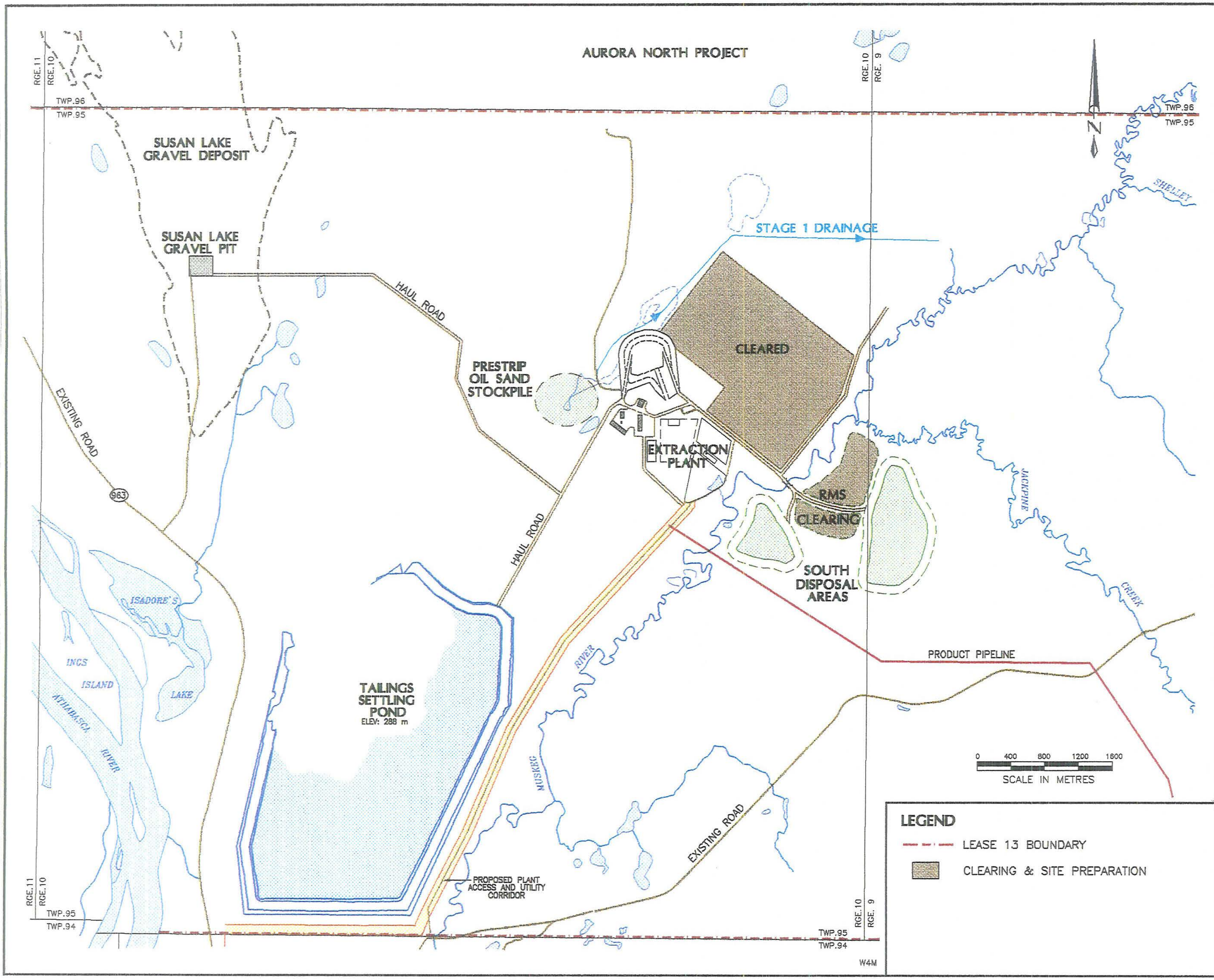


Figure 3-12: Mine Development and Reclamation Progression Plan, Year Ending 2001

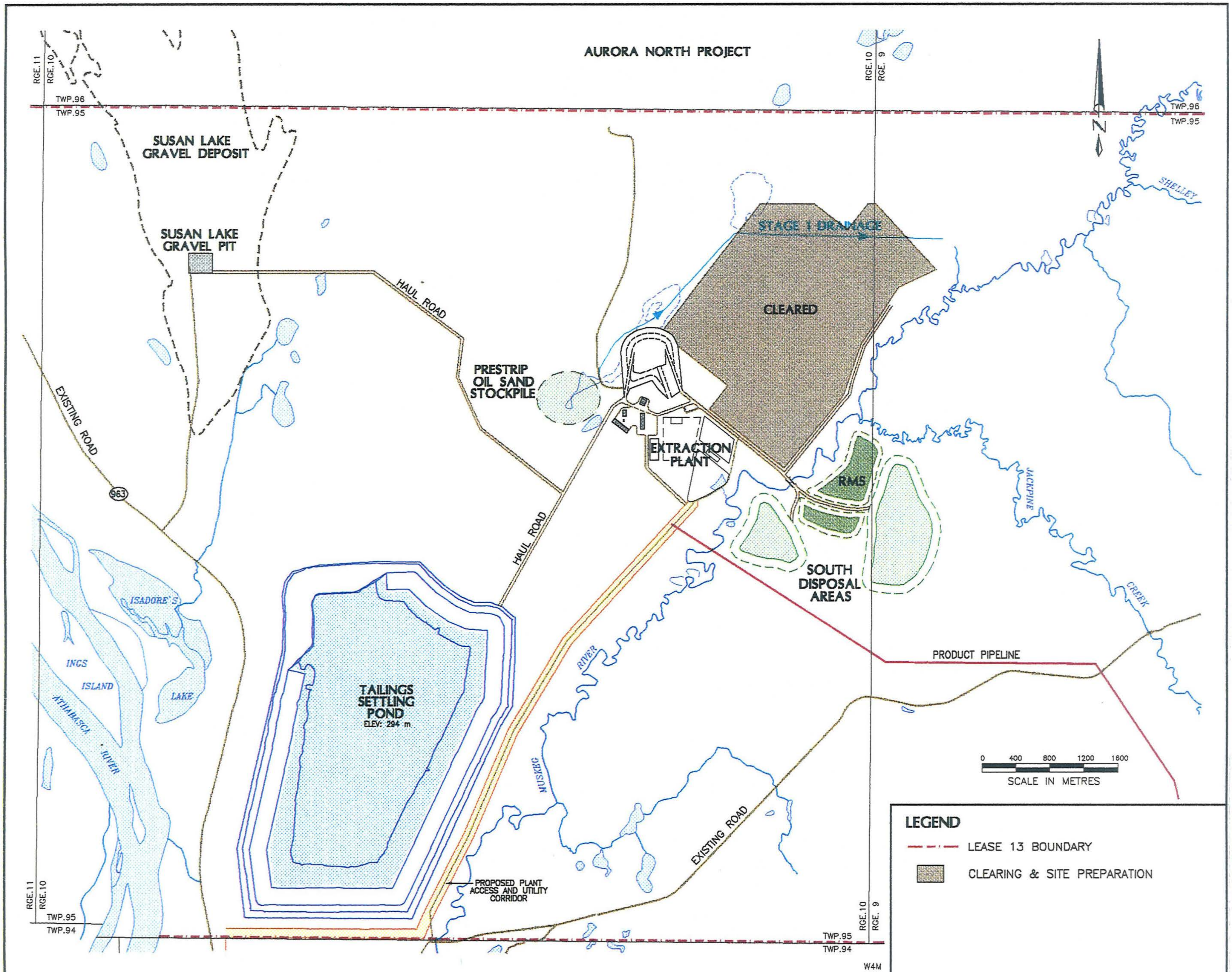


Figure 3-13: Mine Development and Reclamation Progression Plan, Year Ending 2002

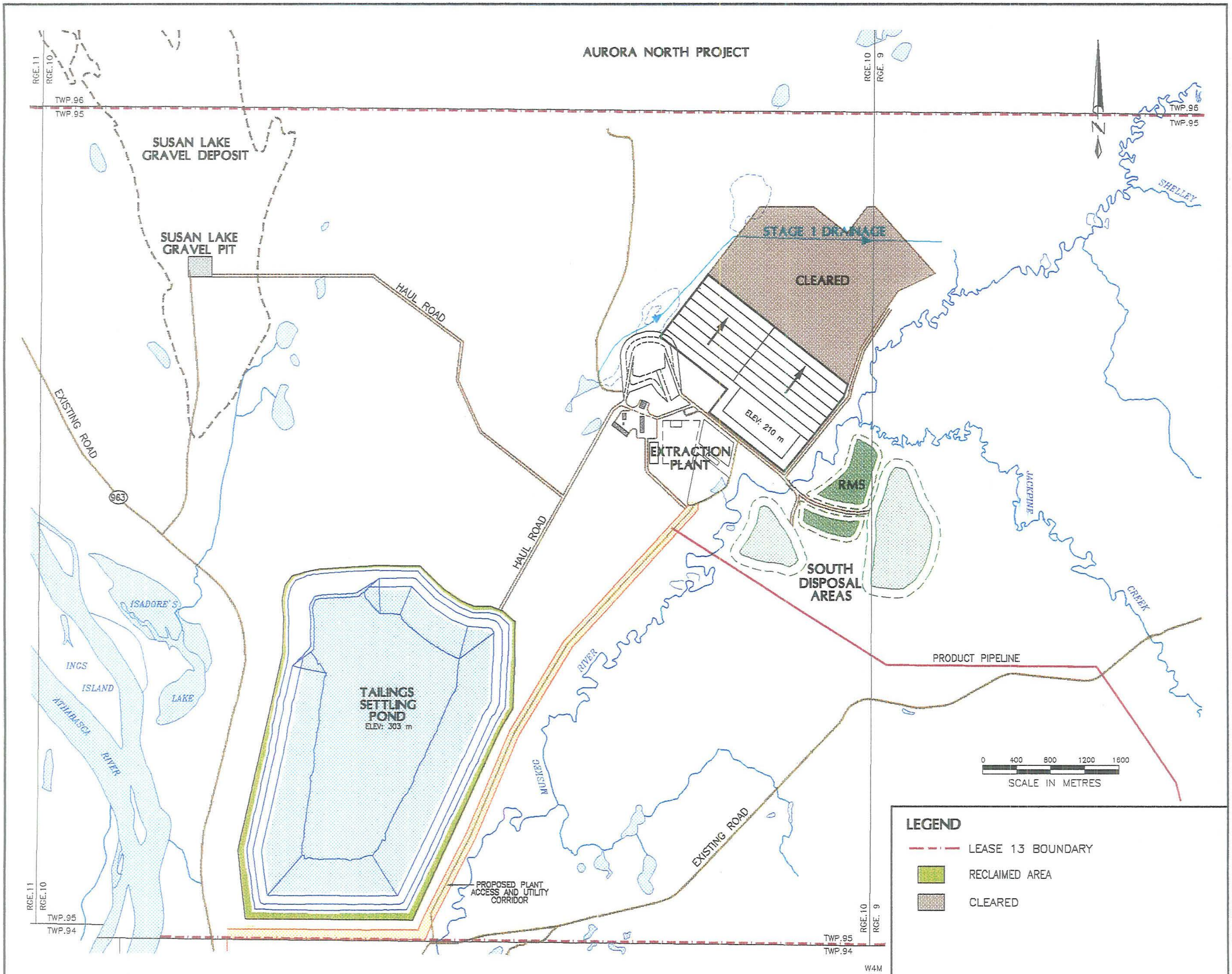


Figure 3-14: Mine Development and Reclamation Progression Plan, Year Ending 2003

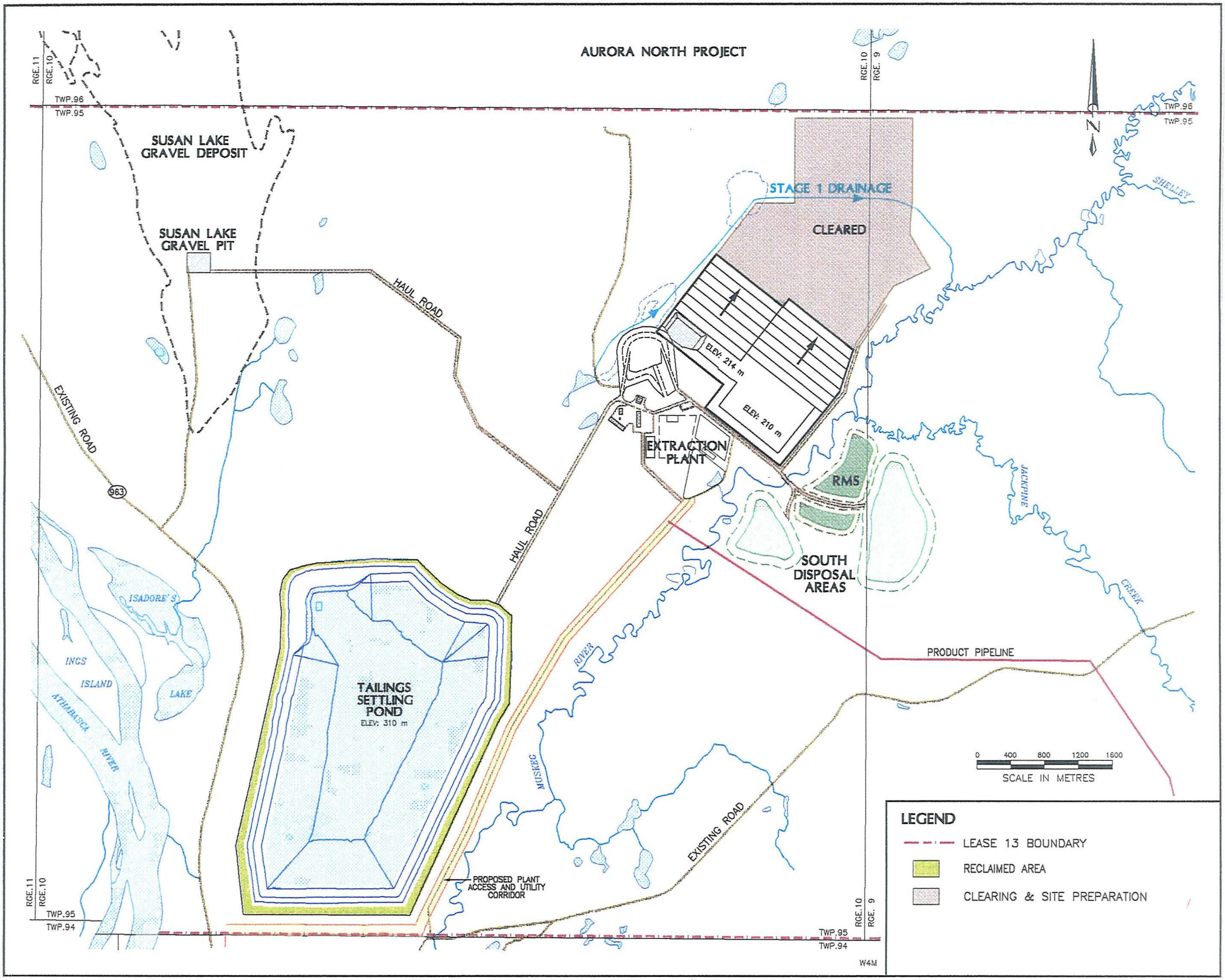


Figure 3-15: Mine Development and Reclamation Progression Plan, Year Ending 2004

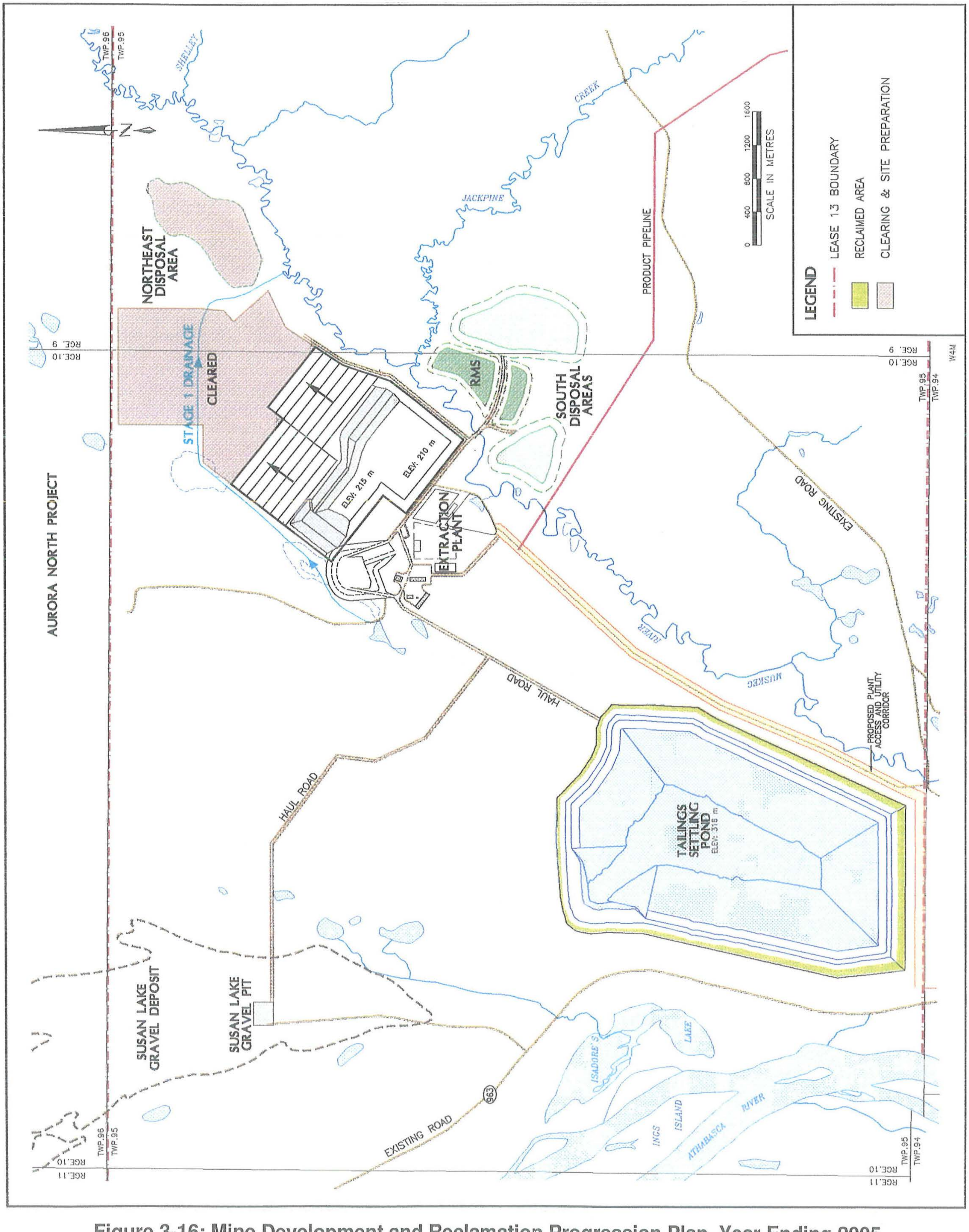


Figure 3-16: Mine Development and Reclamation Progression Plan, Year Ending 2005

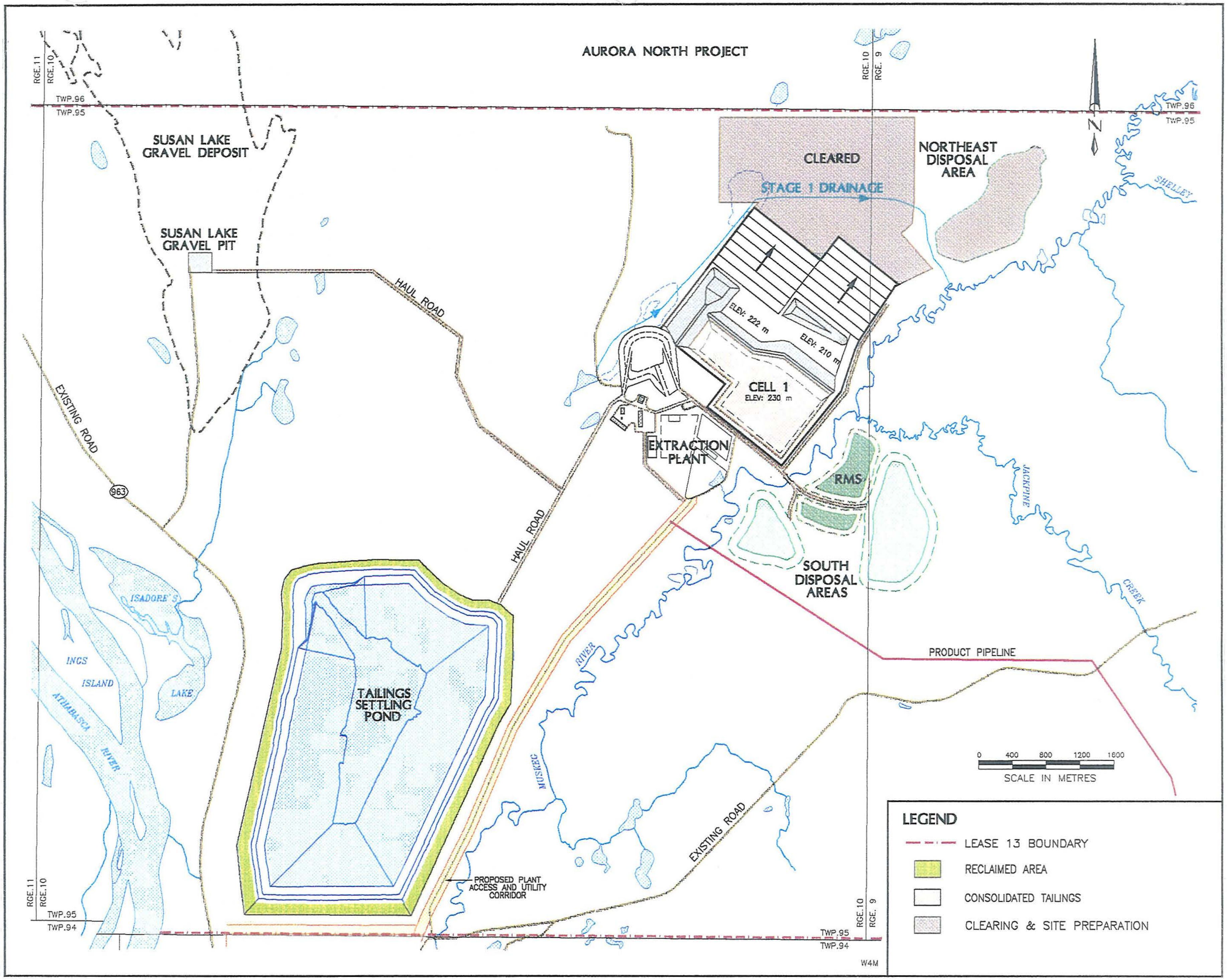


Figure 3-17: Mine Development and Reclamation Progression Plan, Year Ending 2006

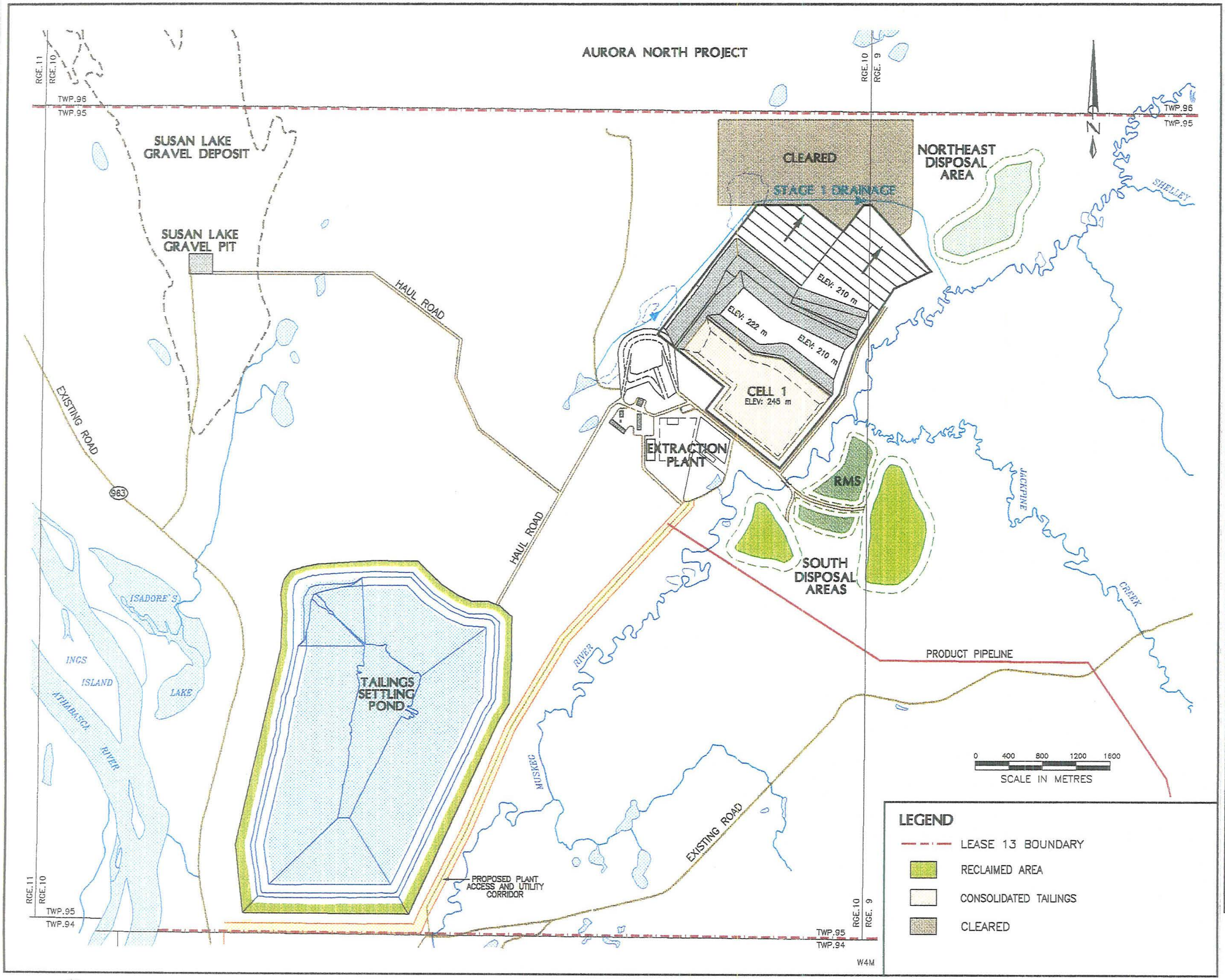


Figure 3-18: Mine Development and Reclamation Progression Plan, Year Ending 2007

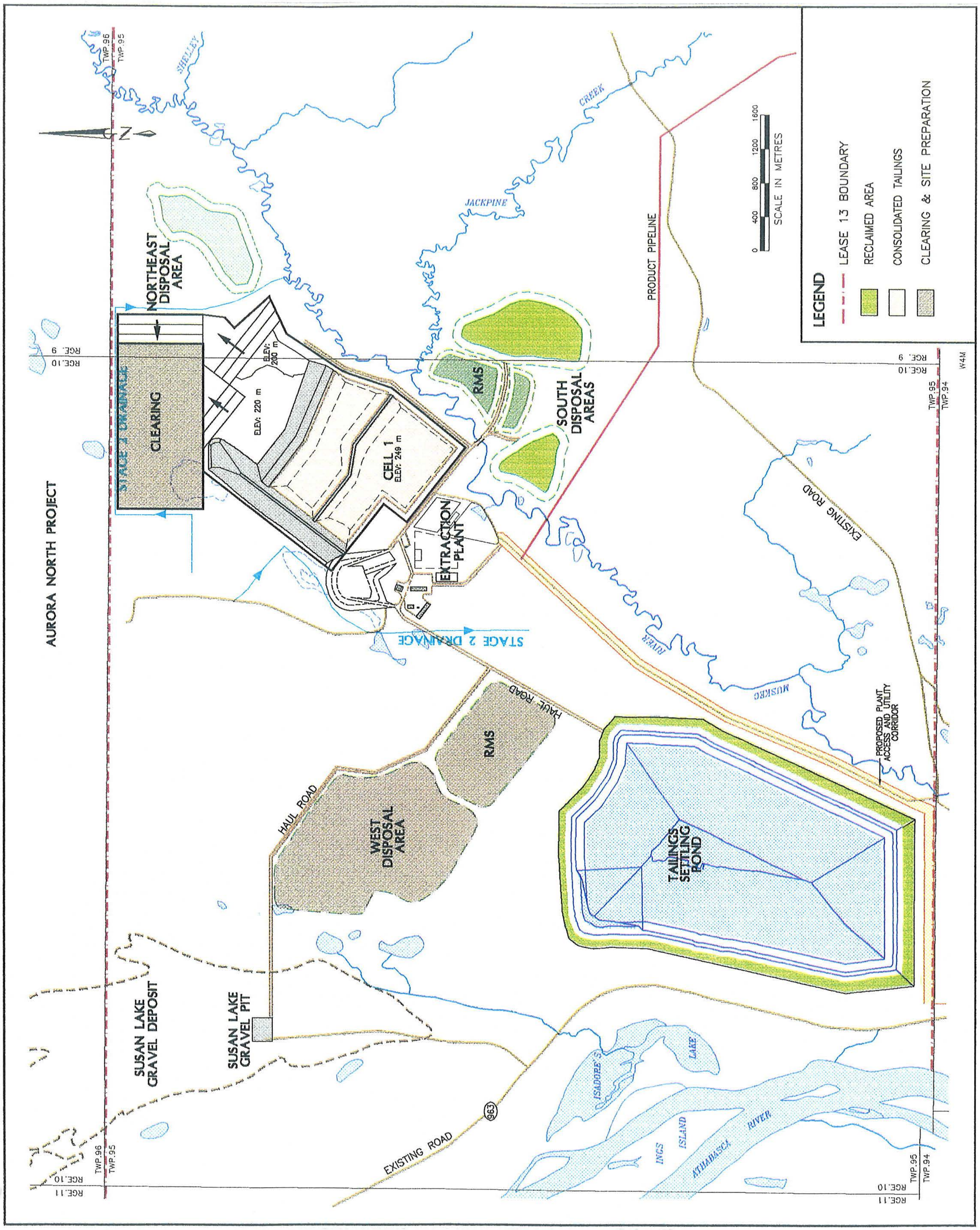


Figure 3-19: Mine Development and Reclamation Progression Plan, Year Ending 2008

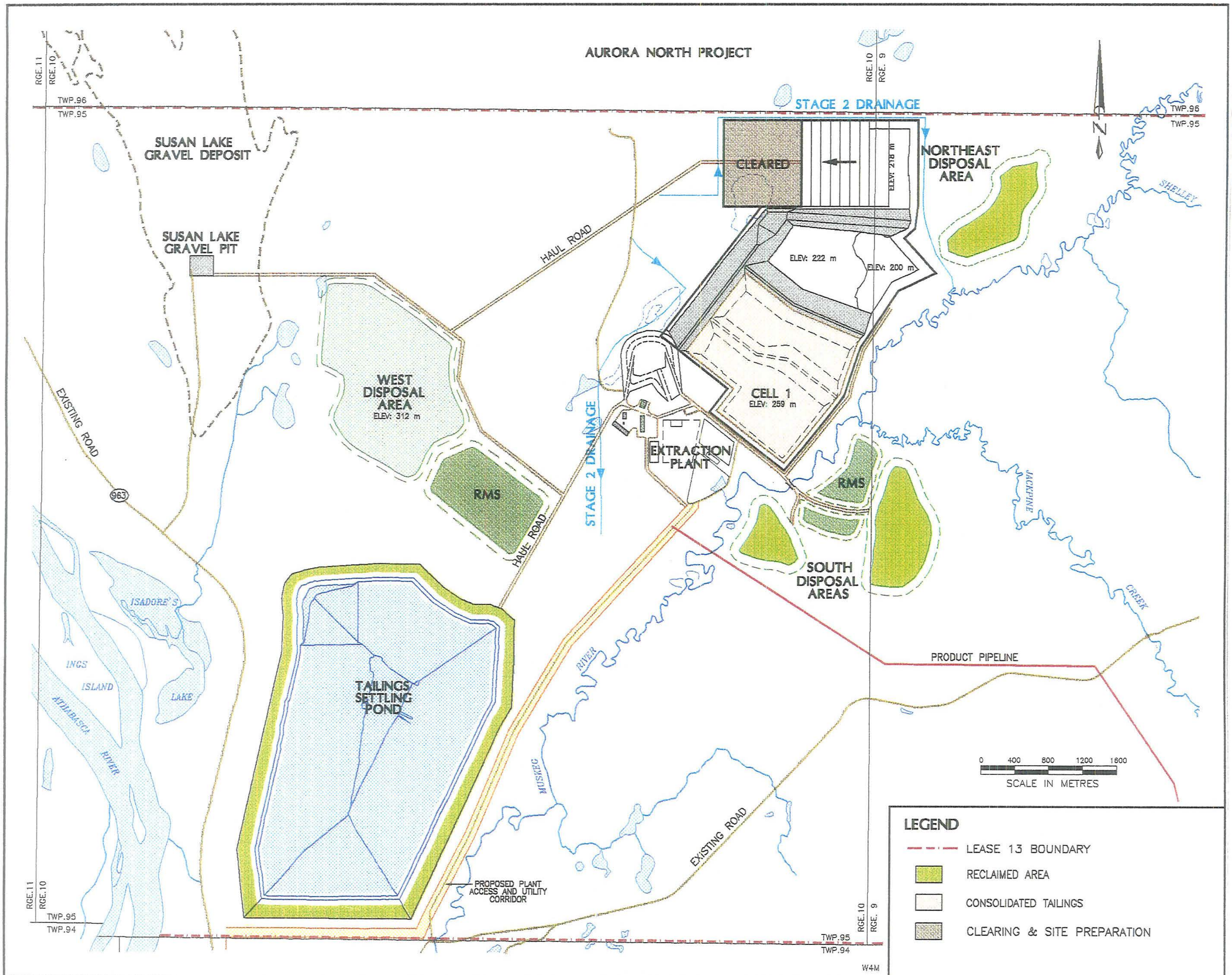


Figure 3-20: Mine Development and Reclamation Progression Plan, Year Ending 2009

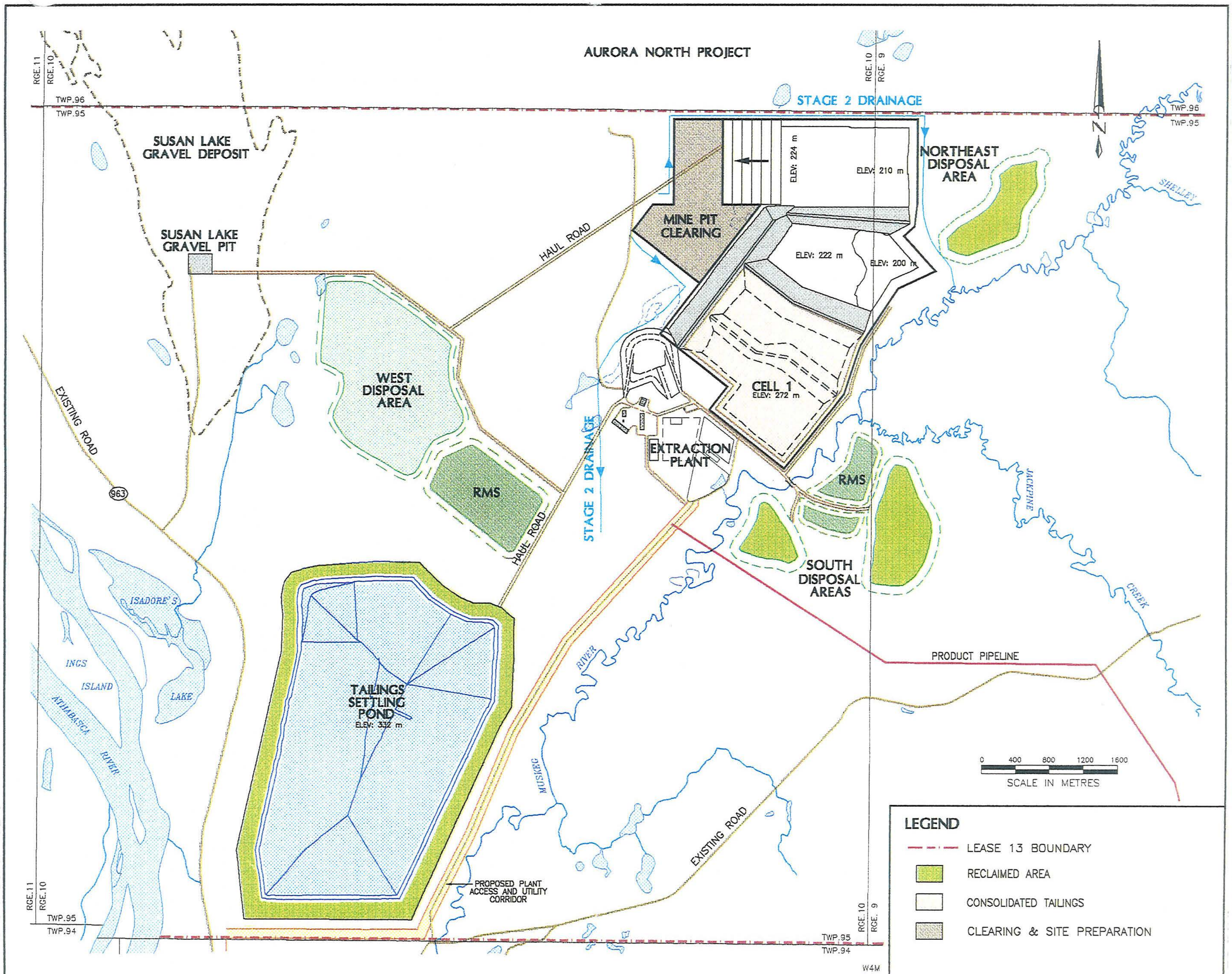


Figure 3-21: Mine Development and Reclamation Progression Plan, Year Ending 2010

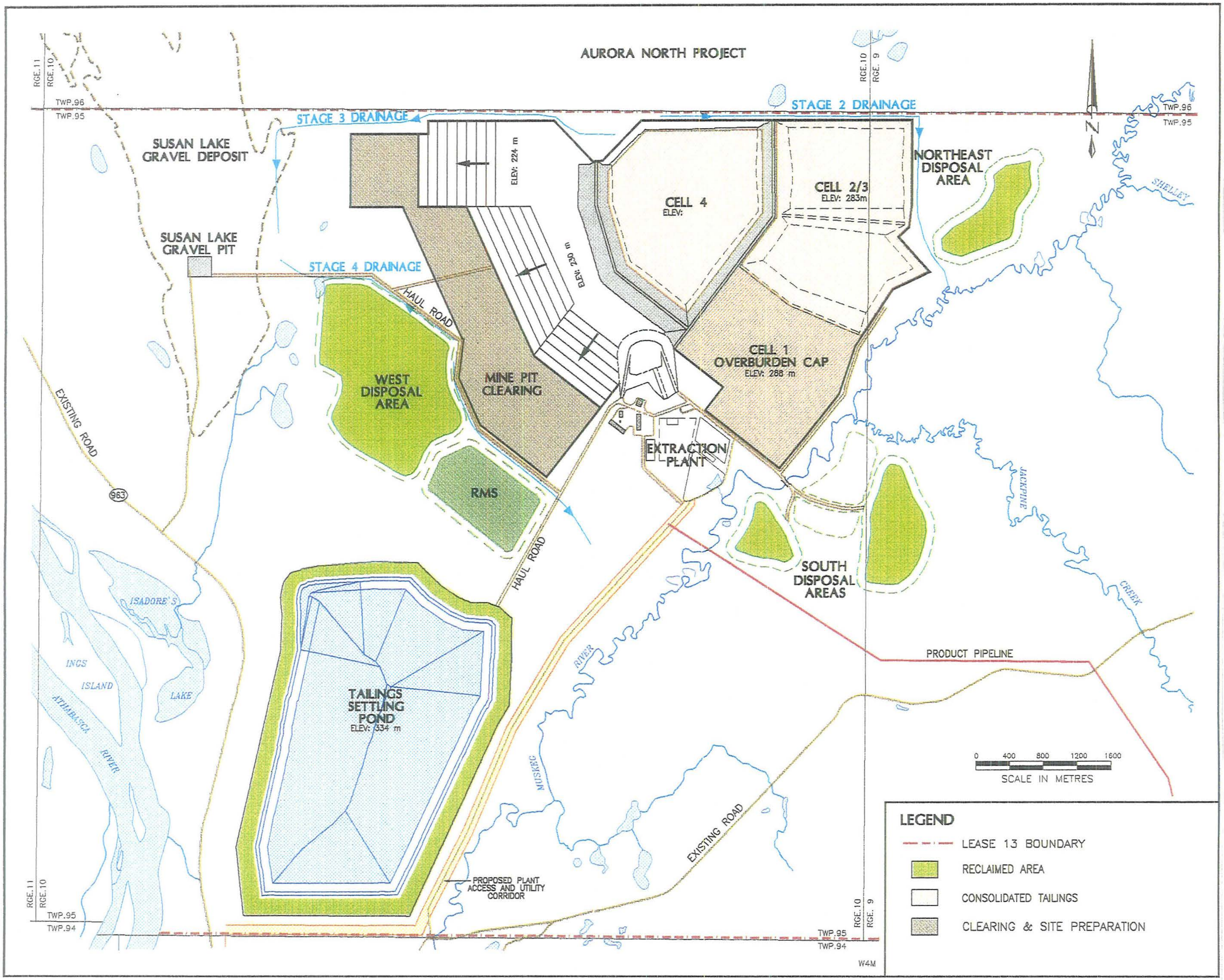


Figure 3-22: Mine Development and Reclamation Progression Plan, Year Ending 2016

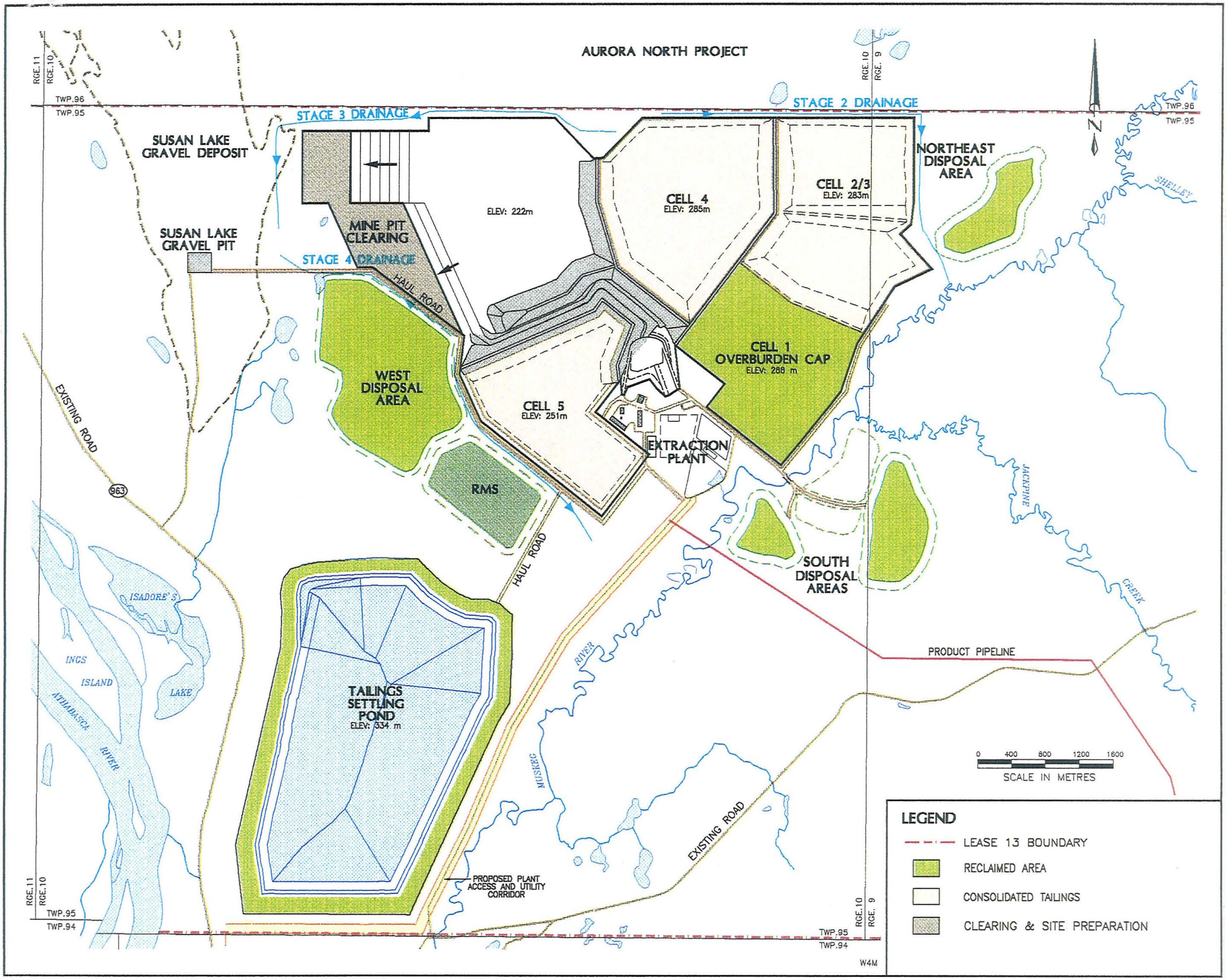


Figure 3-23: Mine Development and Reclamation Progression Plan, Year Ending 2020

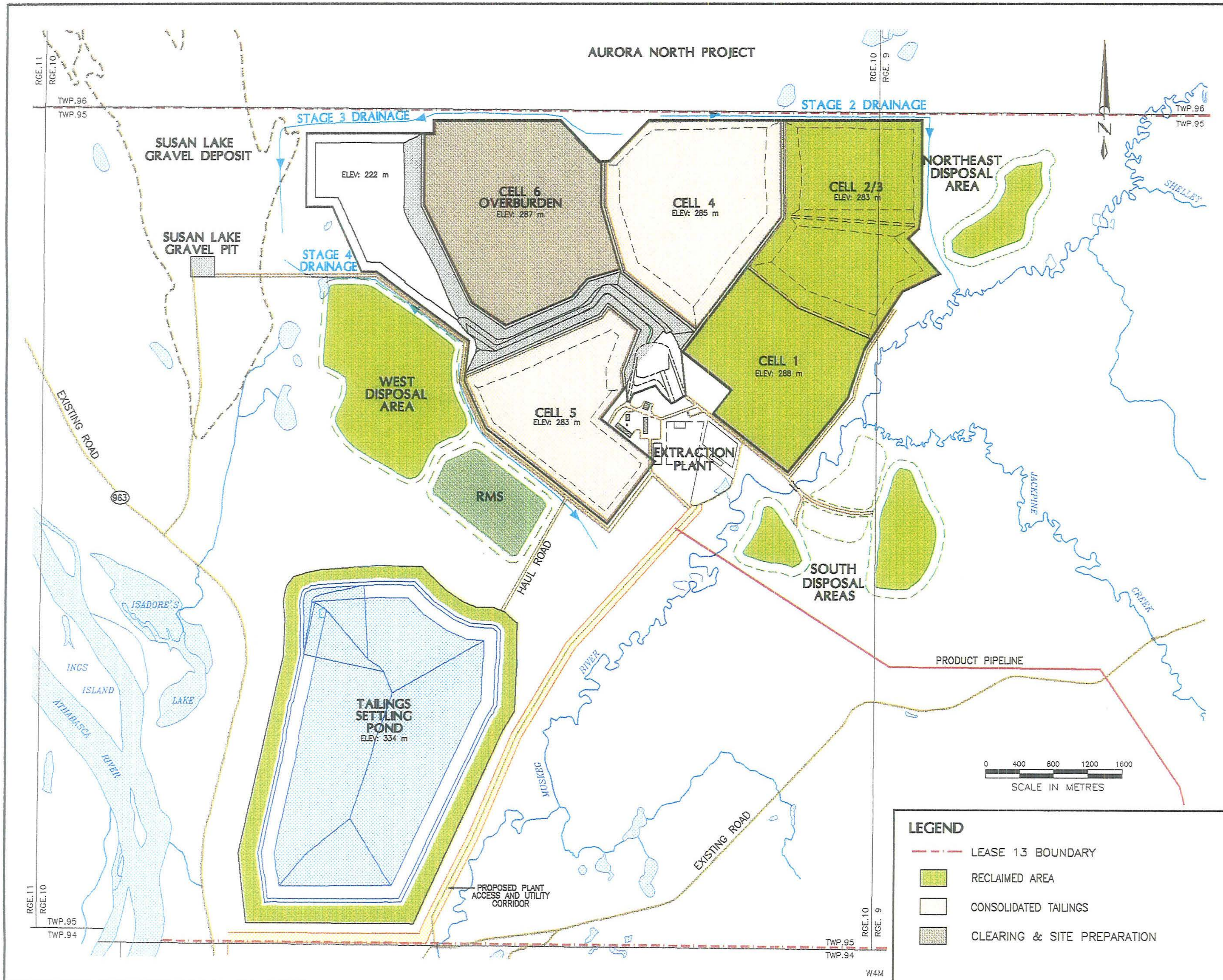


Figure 3-24: Mine Development and Reclamation Progression Plan, Year Ending 2022

SCOPE

A significant amount of interest has been expressed about the status of the project's utilities. This section provides an overview of the key components of the utility and infrastructure scope. Definition of these key areas will improve as front-end engineering progresses throughout 1998 and into 1999. Industry regional cooperation will also be defined as the Muskeg River Mine Project progresses and the developments of other potential oil sands participants advance. Consequently, some aspects related to utilities will not be fully defined for some time. The additional regulatory approvals that are required will be sought as decisions are finalized.

ELECTRICAL POWER

Power Generation

The evaluation of electrical power options has not yet led to any conclusions that would change the application base case assumption of grid-connected power. This application base case remains the benchmark against which cogeneration options are being evaluated.

In 1997, Shell evaluated the potential for coordinated cogeneration with Syncrude to provide power for the Muskeg River Mine and Syncrude's Aurora operations. Syncrude has since conducted its own regional review of its utility management options and has decided to optimize its system between the Aurora site and the existing Mildred Lake facility. Consequently, there is no longer an opportunity for coordinating cogeneration between the Aurora and Muskeg River developments. The possibility of sharing transmission facilities and options for increased overall system reliability through back-up power support will be explored with Syncrude.

Shell is now proceeding with its own review of cogeneration potential, including assessing the electrical market and future pricing as well as the costs of cogeneration facilities relative to the application base case of Alberta grid-connected power supply.

Electrical Transmission

The application base case for electrical transmission is two 144 kV transmission lines from the Alberta electrical grid to the Muskeg River Mine. The potential for coordinated electrical transmission is being pursued with Syncrude. Discussions have been initiated on the prospect of sharing access to Syncrude's proposed transmission line from Aurora North to Mildred Lake. Shell would still require a

Electrical Transmission (cont'd)

second transmission line to ensure adequate reliability for power delivery from the Alberta grid.

Details of the transmission line routing beyond the Lease 13 site are still to be confirmed. Shell will ensure that any transmission line crossing of the Athabasca River achieves adequate vertical clearance above the water. The exact location of any crossing will be determined, then discussed with the relevant regulatory agencies. The routing of Syncrude's utilities will be a key consideration in determining the routing of Shell's utilities.

NATURAL GAS SUPPLY INFRASTRUCTURE

Shell has actively participated in the Industry Natural Gas Infrastructure Group, involving Shell, Syncrude, Petro-Canada and Mobil. Efforts continue to determine the most cost-effective means of providing mainline natural gas infrastructure for the region, as well as individual laterals to the various project developments. Shell believes that a regional transportation solution is possible. However, if a regional transportation solution is not found, Shell will arrange for a dedicated system.

When a natural gas supply infrastructure option has been selected, the details of the route to Lease 13, and any required Athabasca River crossing, will be finalized.

COMMUNICATIONS NETWORKS

Telephone and data communications networks have not yet been a focus area. Shell expects to evaluate and define communications network options during front-end engineering.

SITE ACCESS VIA HIGHWAY 63

Shell intends to use the existing route from the Lease 13 site and the existing crossing of the Athabasca River via the Peter Lougheed Bridge.

WATER INTAKE

Intake Design

Four options for intake design were provided in the application. As a result of a more detailed evaluation, a fifth option has been identified and selected. The selected intake option is a wedge design, which includes:

- an in-stream concrete intake adjacent to the river bank
- three pipelines connecting the intake to a pumphouse set back from the riverbank
- the installation of fish screens to protect fish from the pumphouse intake

Figure 4-1 shows a conceptual layout for this type of intake structure. A plan view is shown in Figure 4-2.

This intake design has been selected as the preferred option because it has a:

- low impact on fish habitat
- reduced impact from high sediment loads in the Athabasca River
- negligible visual impact from the Athabasca River

The in-stream facilities required for this option will be designed to meet Coast Guard requirements for maintaining navigation of the river.

Sites Considered

Two sites were considered in the application:

- barge landing site
- Isadore's Lake

A rock filter intake structure was considered for the barge landing site. Induced water wells from thick sand deposits were considered for the Isadore's Lake site.

Subsequent investigation of the Isadore's Lake site using electrical resistivity tomography (ERT) has indicated that there is no hydraulic connection between the thick sand deposit below Isadore's Lake and the Athabasca River. The investigation also concluded that the thick sand deposit might be saturated with highly saline water. Given these results, and feedback from stakeholders,

Sites Considered (cont'd)

Isadore's Lake is not considered suitable for an induced water well intake and the option will not be pursued.

During consultation with stakeholders and further review of possible intake locations, an additional site for a river intake was identified. This site is about 6.5 km downstream of the barge landing site adjacent to a narrow section in the river channel opposite Ing's Island. This site has better hydraulic conditions, can be easily accessed from Highway 63 and is in an area already disturbed by the construction of an old landing site. This site should result in less disturbed area and also provide for a more direct route to the Muskeg River Mine extraction facilities. Figure 4-3 shows this site in relation to the barge landing site.

Shell proposes the Ing's Island site as the preferred water intake location.

Fish Habitat

The fish species present are the same for both the barge landing site and the Ing's Island site. Table 4-1 identifies these species and the applicable timing constraints that recognize spawning and egg incubation periods of the most prevalent species.

No critical or sensitive fish habitat has been identified in the location of either intake site. Shell will prepare a detailed habitat map before and after construction. The intake will be designed to ensure that there is no net loss of fish habitat. Opportunities to enhance habitat through the design of the intake will be evaluated.

Intake water velocities will be managed to meet regulatory requirements.

Table 4-1: Fish Species and Timing Constraints

Species	Timing Constraint
Lake whitefish	October 1 to May 30
Northern pike	April 15 to July 15
Walleye	April 15 to June 30
Goldeye	May 15 to August 15
Burbot	None
Forage fish	None
Source: Alberta Environmental Protection, Fish and Wildlife Division, Fisheries Habitat Protection Guidelines (1992)	

Construction

In-stream activities will be carried out as much as possible outside of the timing constraints. If necessary, a cofferdam will be used to isolate the construction activity from the river. The cofferdam will be constructed outside of the timing constraint periods. Where possible, precautions will be taken to reduce additional sedimentation caused by construction activity.

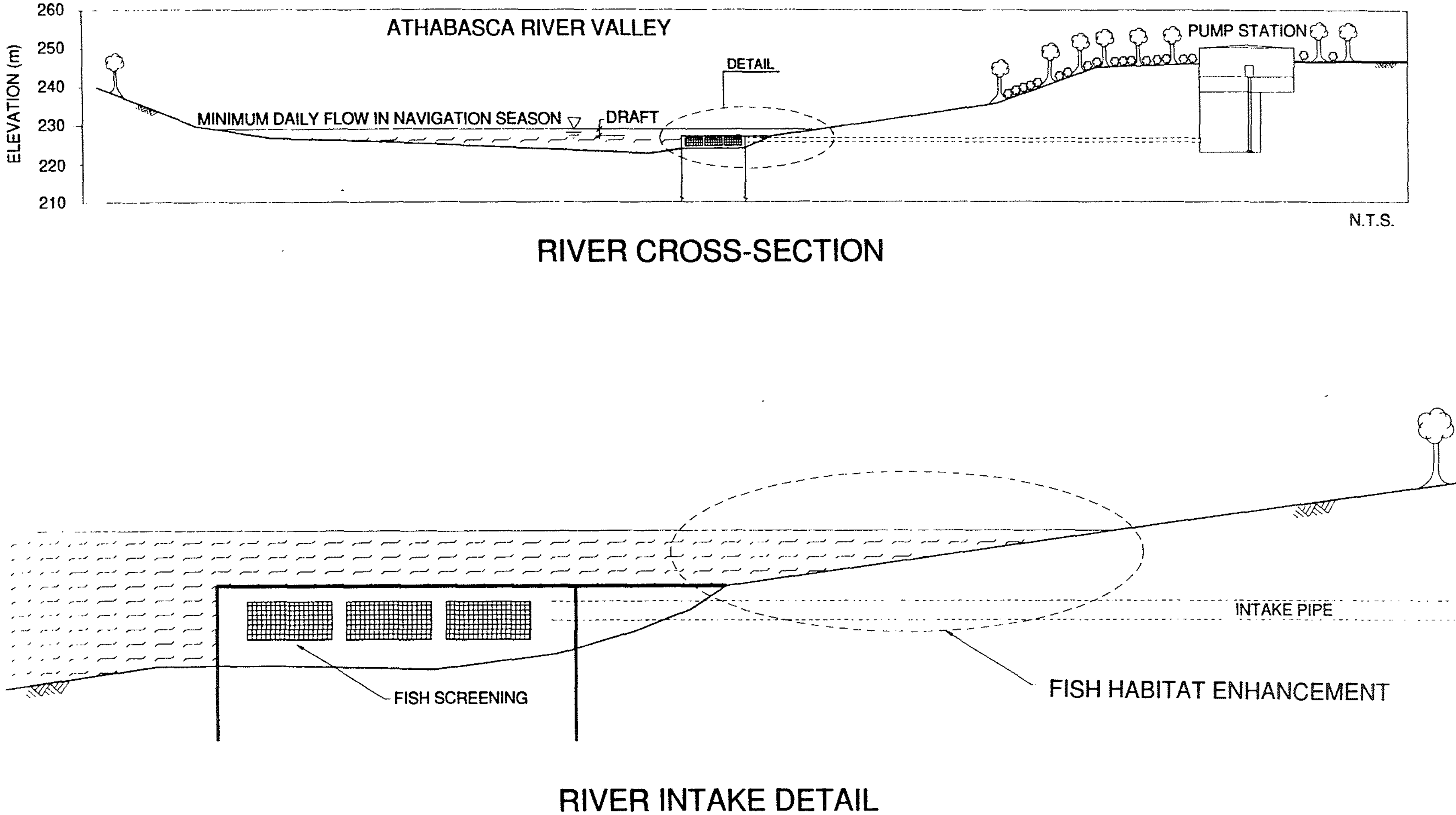


Figure 4-1: Water Intake Conceptual Layout

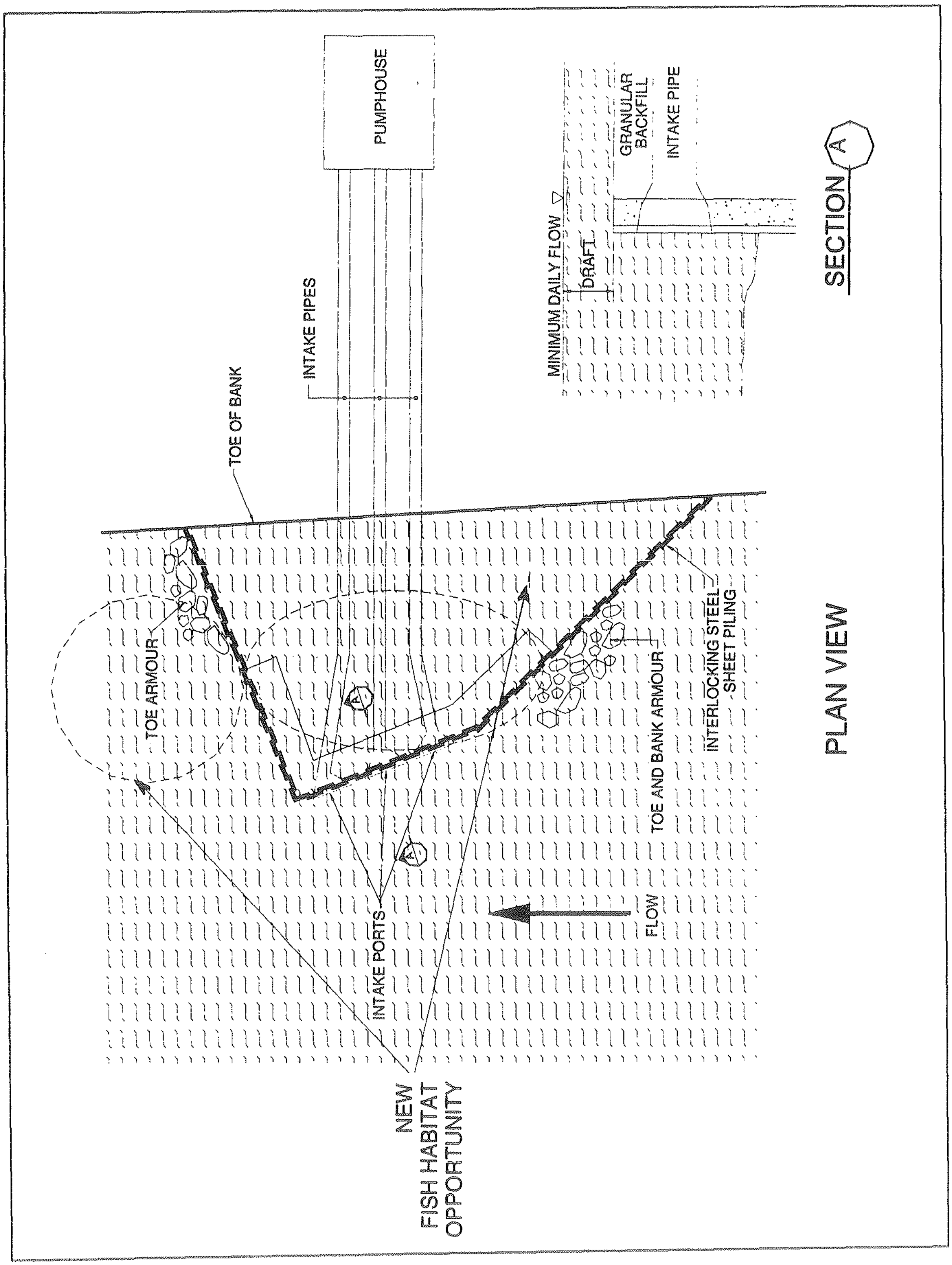


Figure 4-2: Water Intake Plan View

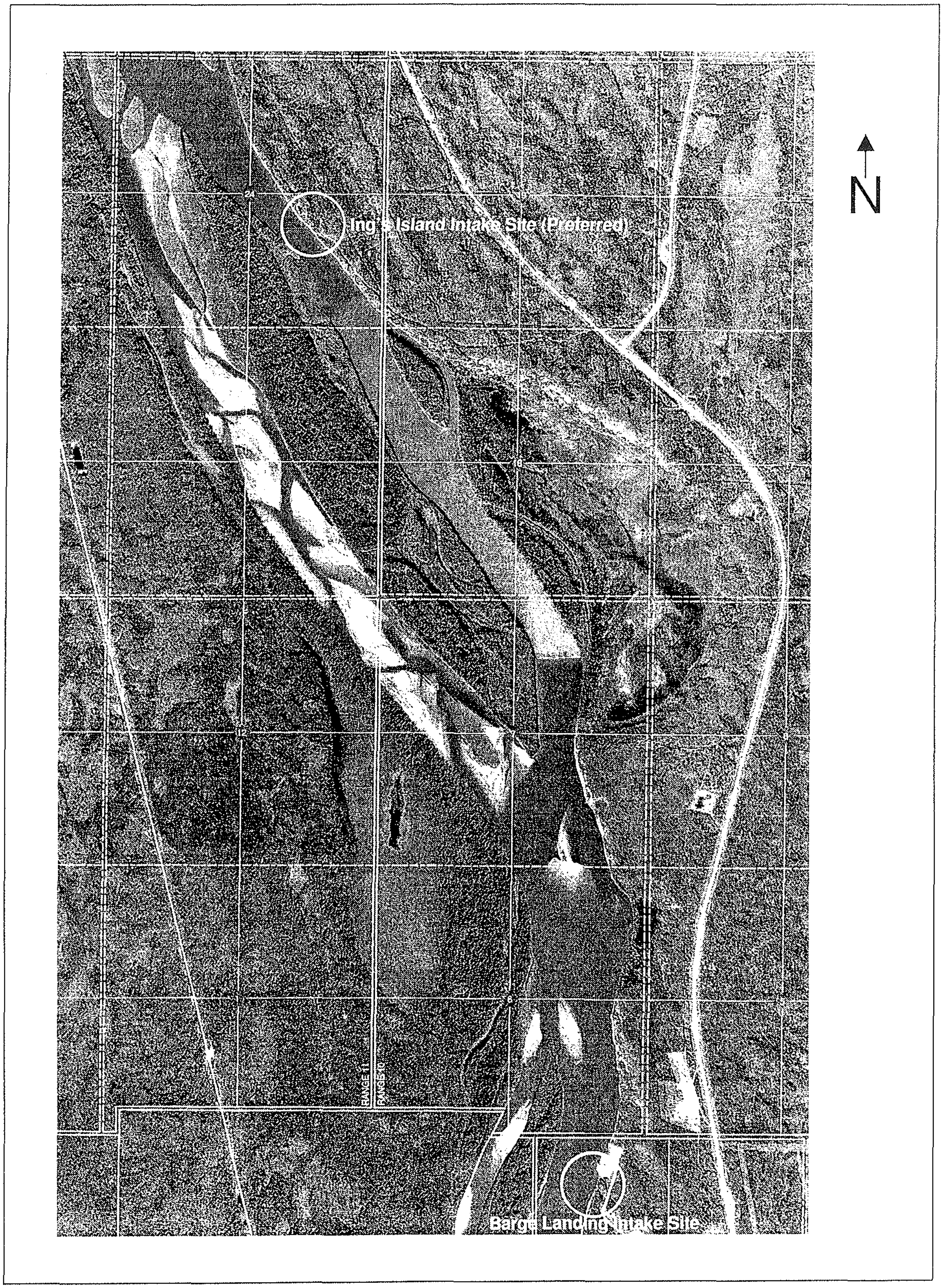


Figure 4-3: River Intake Site Location Options

REVISED HEATING VALUES FOR ENERGY BALANCES

The value for energy content (BTU value) for bitumen used in the application for approval was 44.0 GJ/t higher heating value (HHV). This value was based on an evaluation carried out during the Alsands Project.

Recent work, including work by the Alberta Oil Sands Technology and Research Authority (AOSTRA), has determined a lower value for the energy content of Athabasca type bitumen. A lower energy value was used for design purposes in the proposed Scotford Upgrader, based on bitumen with a reduced asphaltene content. To maintain consistency between the Muskeg River Mine and Scotford Upgrader applications, a value of 42.3 GJ/t (HHV) (or 39.9 GJ/t lower heating value (LHV)) is proposed for bitumen with a reduced asphaltene content. Table 4-2 shows the heating values for bitumen, asphaltene and solvent.

Table 4-2: Heating Value of Muskeg River Mine Energy Balances

Component	HHV GJ/t	LHV GJ/t
Bitumen	41.5	39.2
Bitumen with reduced asphaltene content	42.3	39.9
Asphaltene	22.4	22.4
Solvent	48.5	44.9

MASS BALANCES

The mass balances provided in Volume 1, Figures 9.1, 9.2, 9.6 and 9.7 of the application have been updated to reflect the following changes:

- the solvent required to pipeline the bitumen product has been reduced from 35%, by volume, to 30%, by volume, of the diluted bitumen in the pipeline
- the density of bitumen with reduced asphaltene content has been determined as 0.9997 t/m^3 (at 15°C) compared to a density for bitumen of 1.007 t/m^3 (at 15°C)

The overall mass balance in tonnes per hour is shown in:

- Figure 4-4 – on a calendar day basis
- Figure 4-5 – on a stream day basis

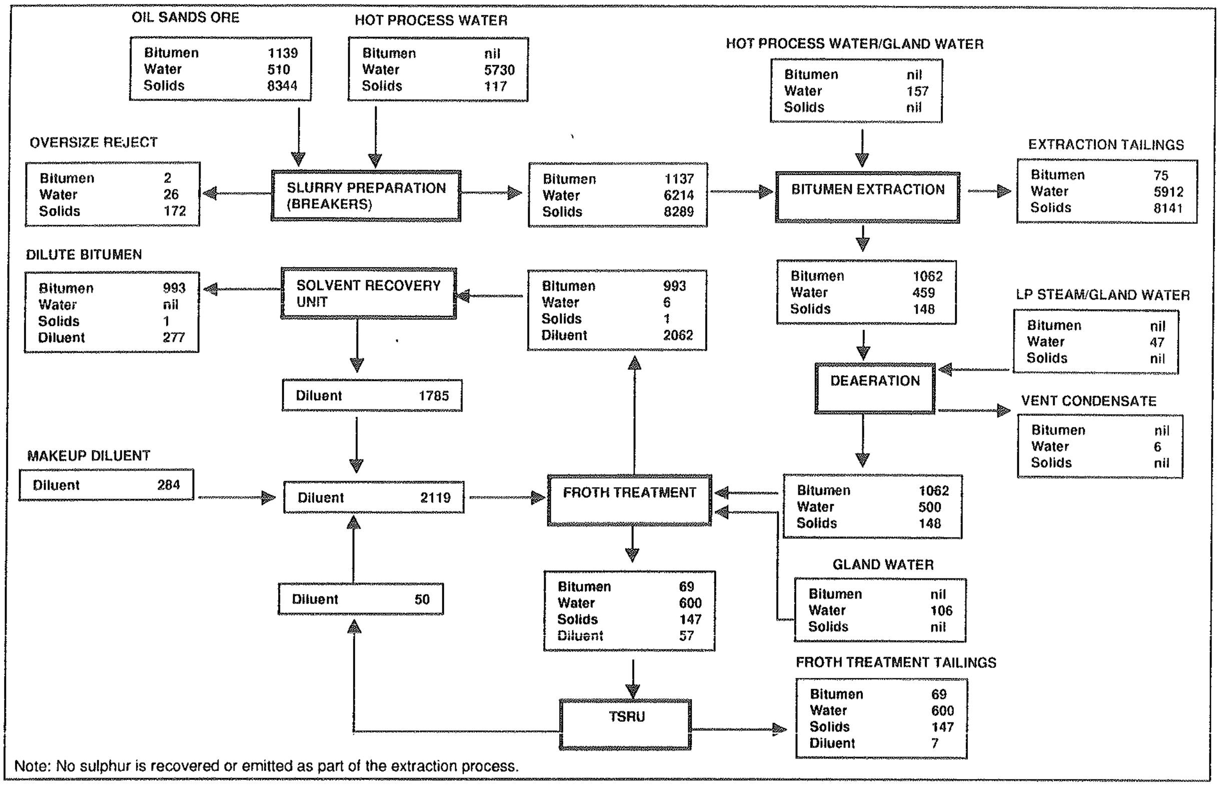


Figure 4-4: Overall Mass Balance Tonnes per Hour (Calendar Day Basis)

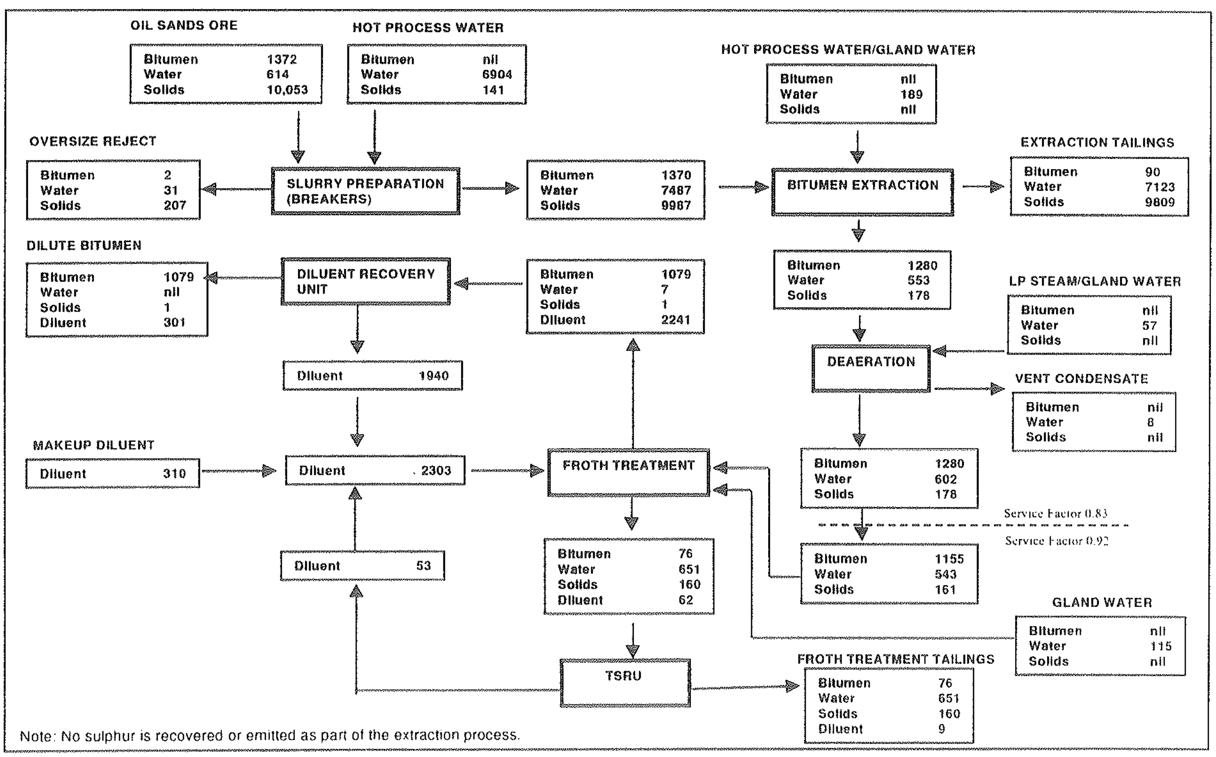


Figure 4-5: Overall Mass Balance Tonnes per Hour (Stream Day Basis)

MASS FLOW BALANCES

Figure 4-6 shows the revised extraction mass flow balance for summer operation on 11.4% grade ore. This balance includes a lower value of 2,191 t/d for the volume of flood water and indicates average process temperatures for froth conditioning, separation, heating and treatment.

The equivalent revised extraction mass balance for winter operation on 11.4% grade ore is shown in Figure 4-7.

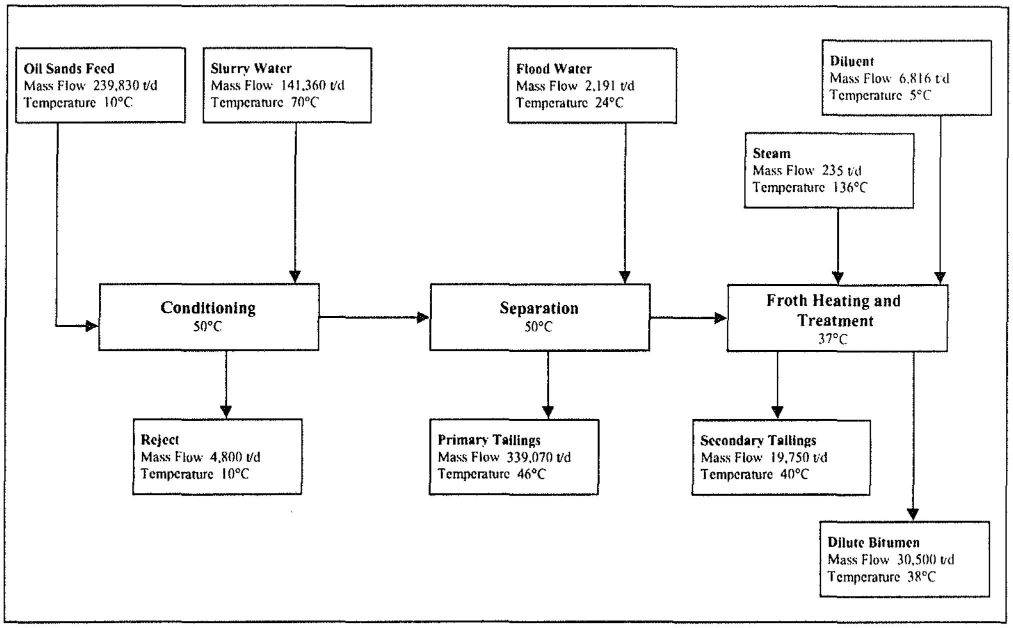


Figure 4-6: Extraction Mass Balance - Summer Operation on 11.4% Grade

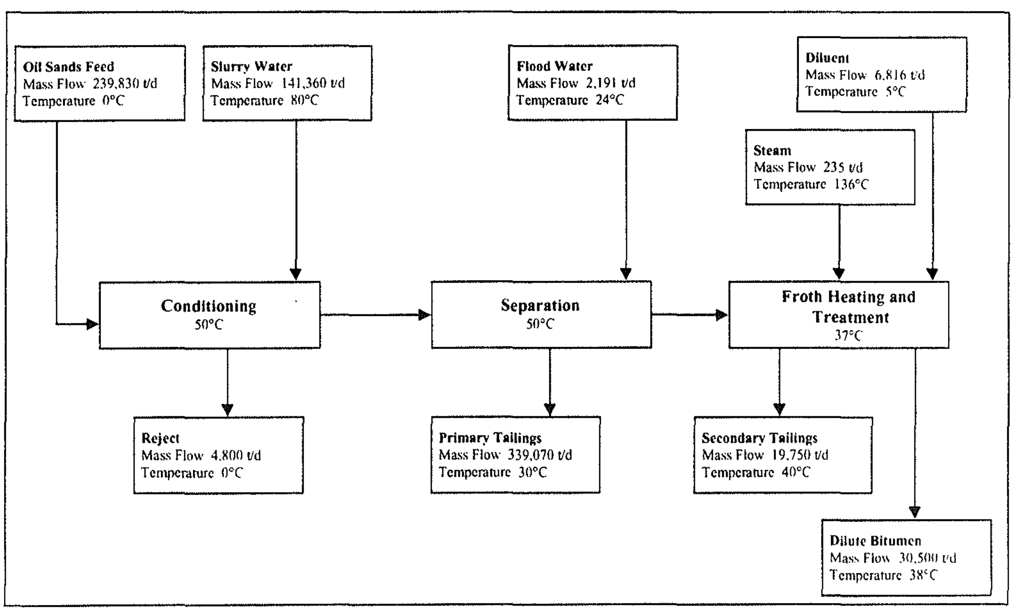


Figure 4-7: Extraction Mass Balance - Winter Operation on 11.4% Grade

HEAT AND ENERGY BALANCES

The energy balances shown in Volume 1, Figures 9-3, 9-4 and 9-5 of the application have been recalculated on an LHV basis and now reflect the energy contents shown previously in Table 4-2 as well as the revisions to the mass balances shown previously in Figures 4-4 and 4-5.

The recalculated heat and energy balances are shown in:

- Figure 4-8 – for summer
- Figure 4-9 – for winter
- Figure 4-10 – annual average

For comparison with existing operations, which complete froth treatment following centrifugation, the energy balances, excluding the product clean-up phase and solvent recovery unit, are shown in:

- Figure 4-11 – annual average
- Figure 4-12 – winter
- Figure 4-13 – summer

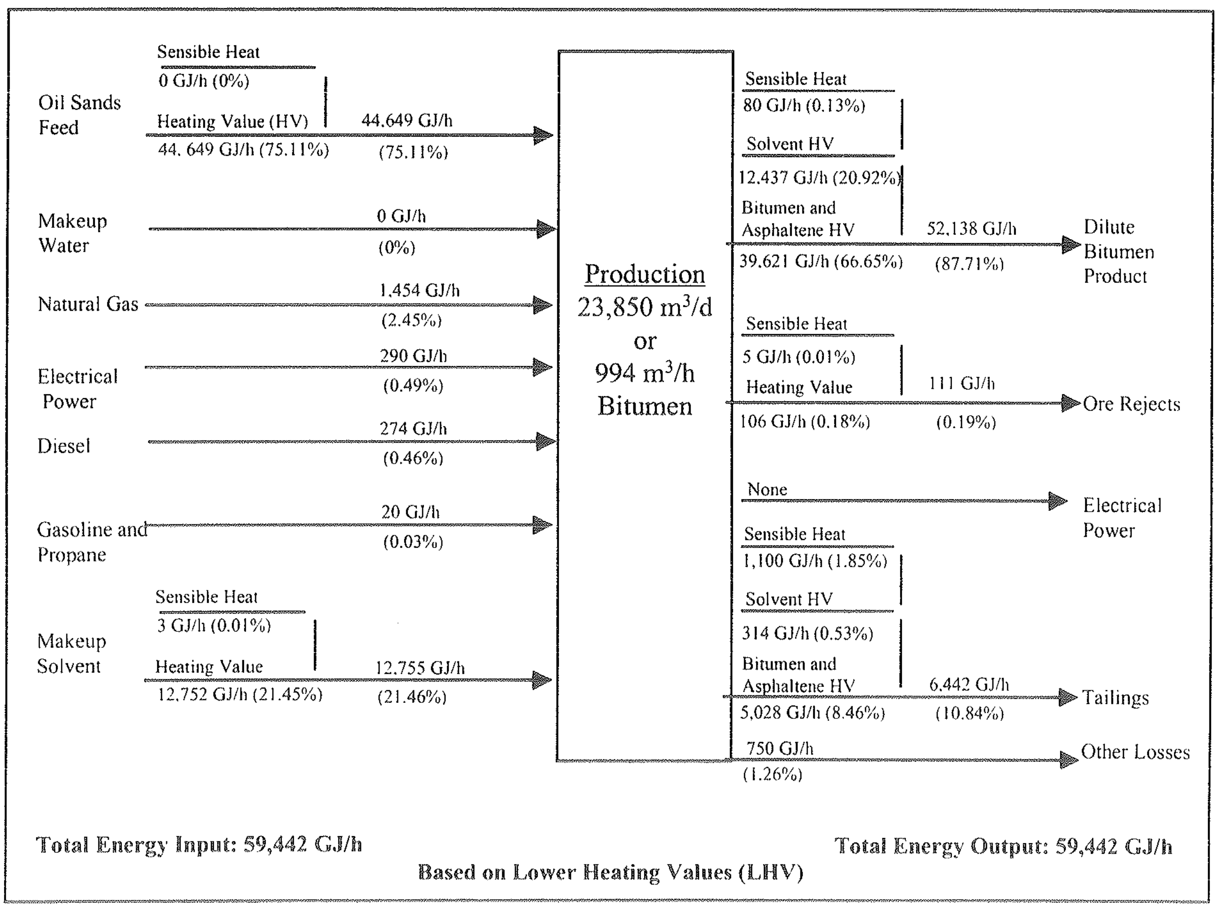


Figure 4-8: Summer Heat and Energy Balance

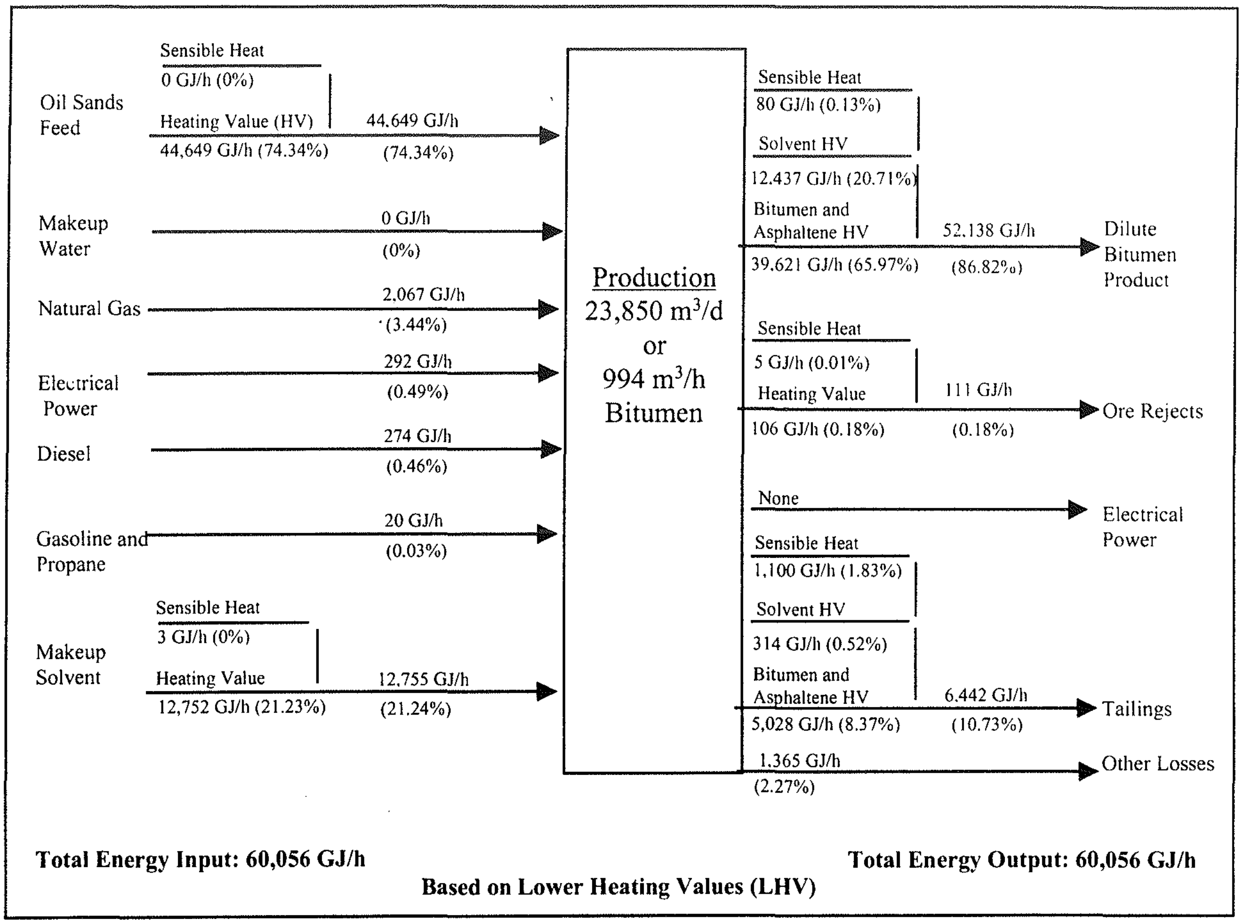


Figure 4-9: Winter Heat and Energy Balance

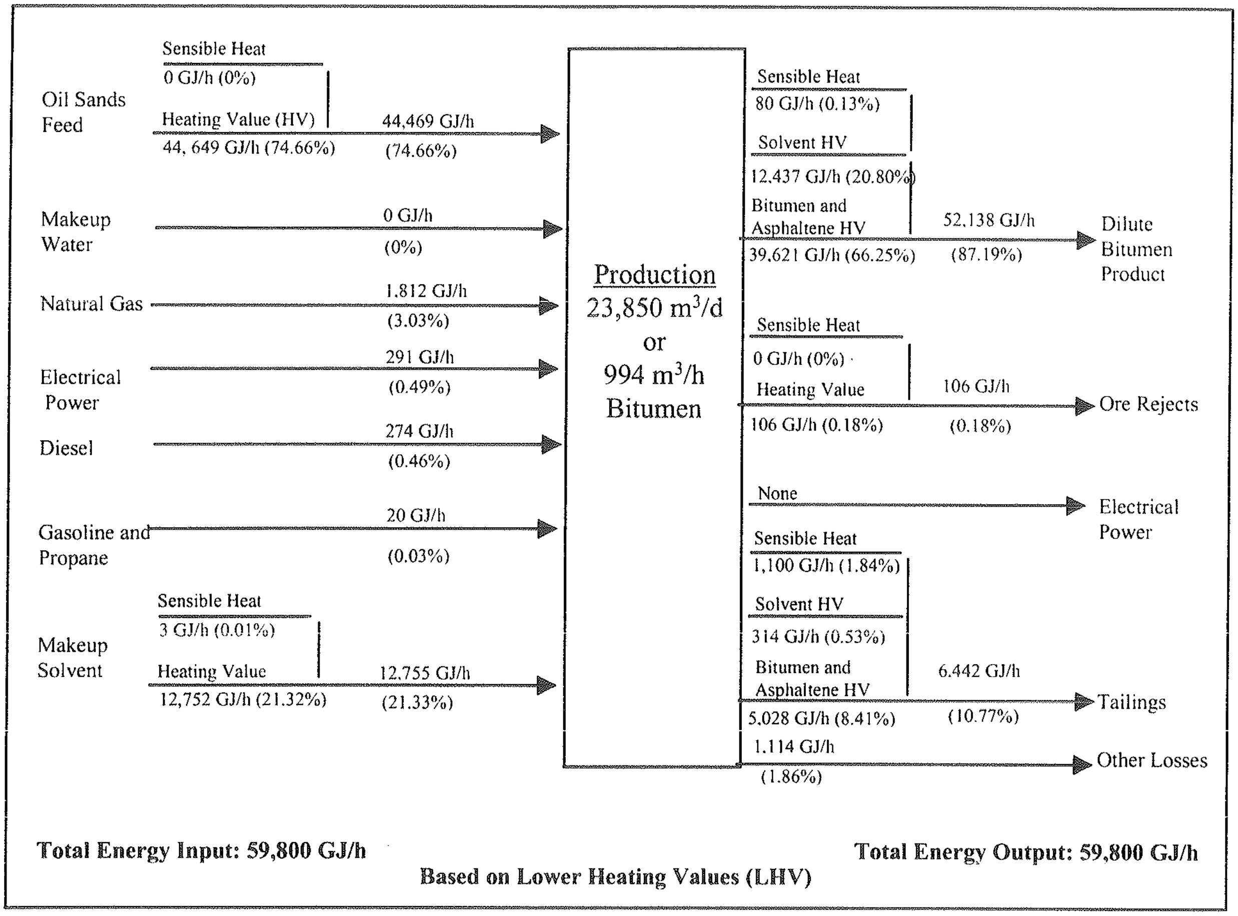


Figure 4-10: Annual Average Heat and Energy Balance

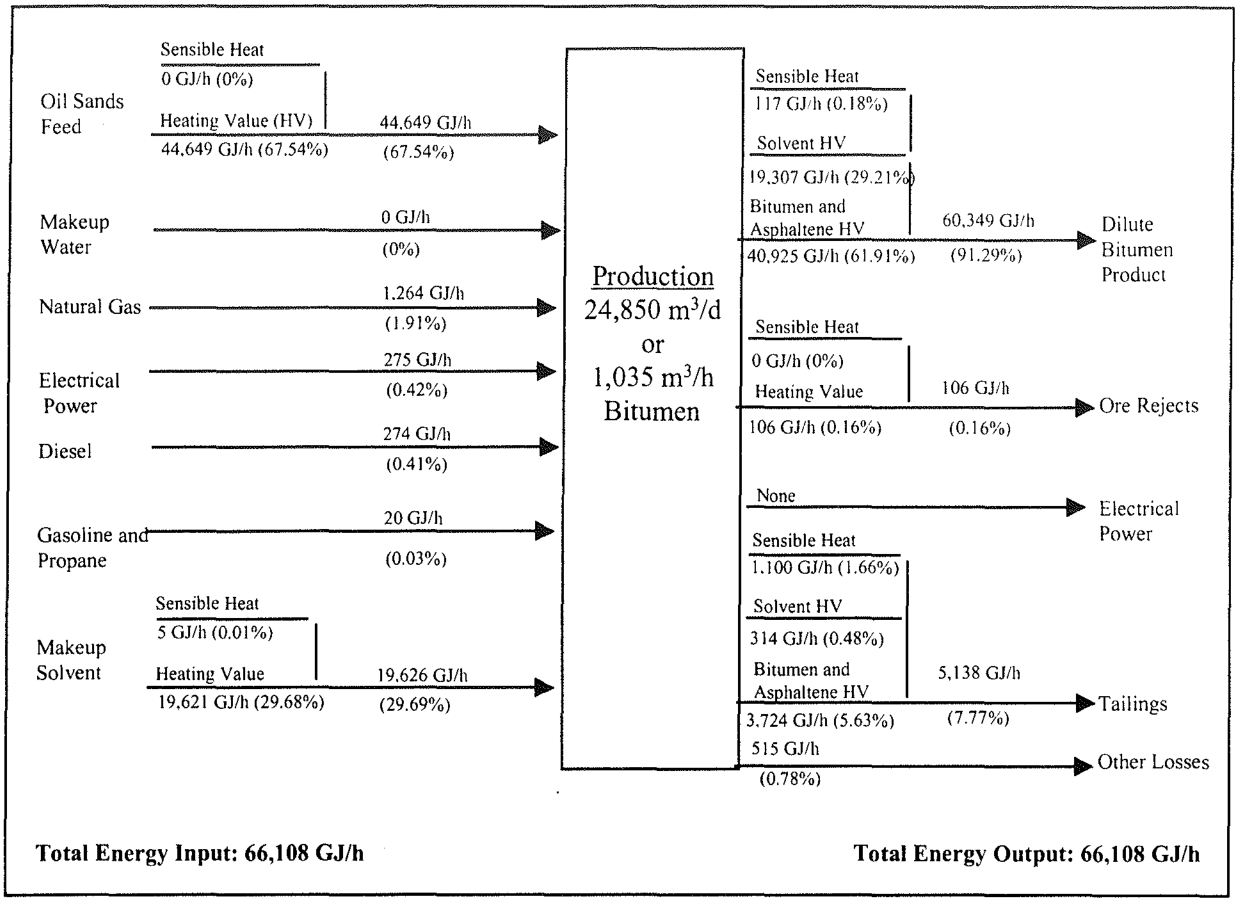


Figure 4-11: Annual Average Energy Balance Excluding Product Clean-Up Phase and Solvent Recovery Unit

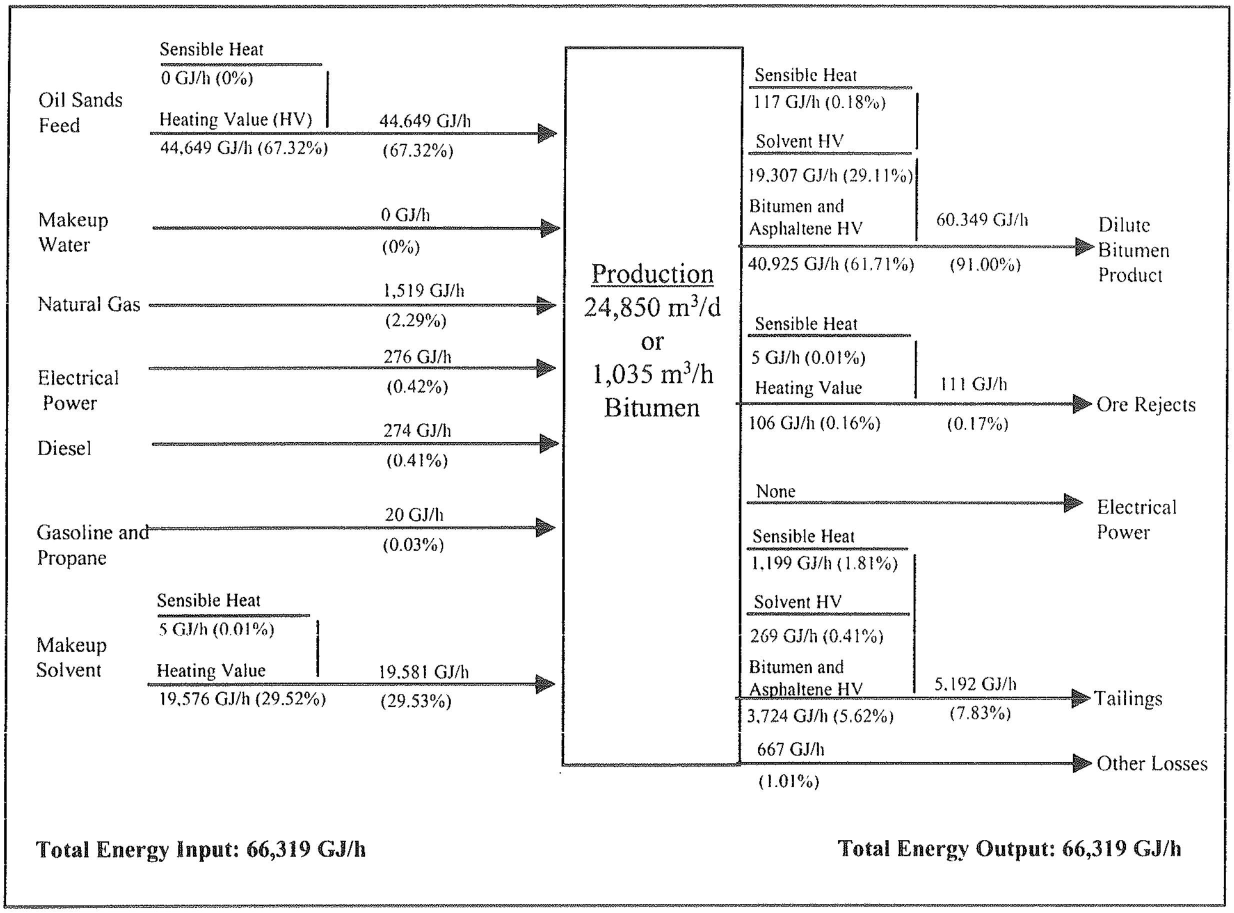


Figure 4-12: Winter Heat and Energy Balances Excluding Product Clean-Up Phase and Solvent Recovery Unit

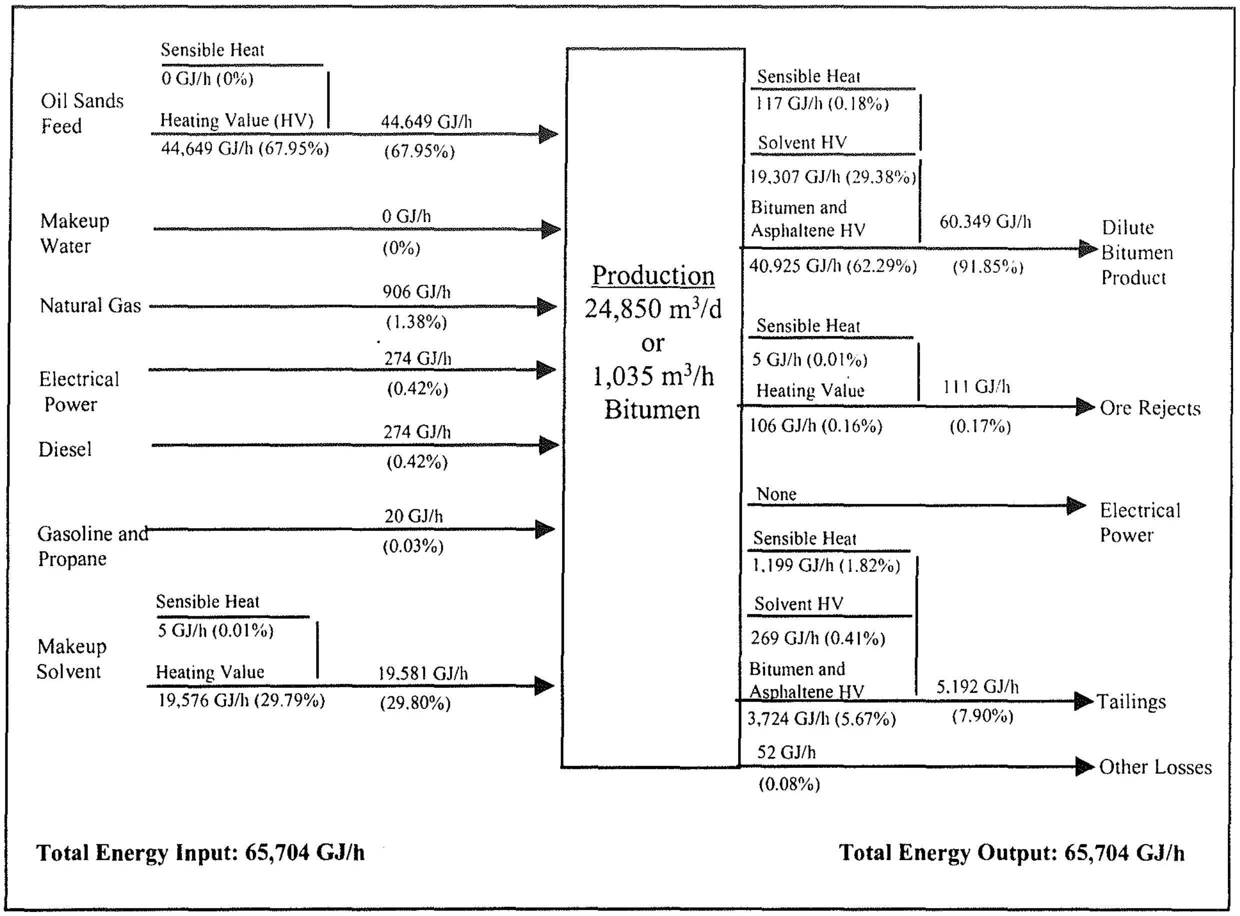


Figure 4-13: Summer Energy Balances Excluding Product Clean-Up Phase and Solvent Recovery Unit

THERMAL ENERGY REQUIREMENTS

Table 4-3 shows the recalculated values for the Muskeg River Mine thermal energy requirements shown in Volume 1, Section 9, Table 9-1.

Table 4-3: Thermal Energy Requirements

Extraction Process	Summer (GJ/m^3)	Winter (GJ/m^3)	Average 444 (GJ/m^3)
Muskeg River Mine	1.53	2.03	1.78

CONSULTATION ACTIVITIES

APPROACH

Shell has continued with its public consultation in the belief that the public should be aware of, and have an opportunity to provide input into, decisions that affect them.

Consultation helps to establish trust and build cooperative working relationships with individuals and groups. It also enables Shell to benefit from the public's input and expertise.

CONSULTATION INITIATIVES

Meetings continue to be held with stakeholders to:

- provide project updates
- discuss and resolve concerns
- pursue opportunities
- develop plans for future activities

Opportunities for Shell to participate in committees and working groups continue to be identified. Stakeholder needs are continuously evaluated and additional meetings, phone calls or correspondence are scheduled as required.

In addition to ongoing consultation with stakeholders and participation in working groups and committees, the following activities continue to support Shell's efforts to solicit feedback and input from the public:

- advertisements
- news releases
- mailouts
- speaking engagements
- a 1-800 project information line

KEY STAKEHOLDERS

In 1998, consultation efforts were directed at working closely with key stakeholders to:

- ensure an understanding of their issues
- work in conjunction with them to resolve any concerns

Community of Fort Chipewyan

Shell continues to meet regularly with the Athabasca Chipewyan First Nation, the Mikisew Cree First Nation and Metis Local 124. The Athabasca Chipewyan First Nation and the Metis Local expressed concern regarding:

- the consultation process
- whether their unique socio-economic and environmental concerns were adequately reflected

In response to these concerns, Shell met, individually and as a group, with representatives of the:

- Athabasca Chipewyan First Nation
- Mikisew Cree First Nation
- Metis Local 124

An action plan was drafted to enable collaboration between these groups for input and review of the EIA. The Athabasca Chipewyan First Nation and Metis Local 124 have agreed to provide their individual input for the Socio-Economic Impact Assessment (SEIA) to add to the information prepared by the Mikisew Cree First Nation.

Work is progressing and Shell expects to receive the final results of these reviews in June. Where required, additional meetings with the individual groups will be held. This will ensure that consultation efforts meet the needs of the community, including the need for further discussions about contracting opportunities and environmental monitoring.

On March 24, 1998, a team of Shell employees hosted a series of Time to Plan career sessions for junior and senior high school students at Athabasca Delta Community school in Fort Chipewyan.

Community of Fort McKay

In addition to the Shell McKay Application Review Team, an Industry Relations Corporation (IRC)–Shell Working Group has formed. The group meets weekly and consists of:

- the Fort McKay IRC Director
- two Fort McKay community liaison workers
- two Fort McKay elders
- one Fort McKay councillor
- one Fort McKay student representative
- other agency representatives, as their time permits

The working group's focus is to:

Community of Fort McKay (cont'd)

- review the community's key concerns
- identify and prioritize issues
- develop short- and long-term mitigation strategies and action plans based on community input
- provide a forum for Shell, community groups and individuals to meet and discuss concerns or potential opportunities for working together. Meetings are scheduled as needed.

Other community activities include:

- contracting workshops for local entrepreneurs
- meetings with trappers
- school visits
- meetings with local business representatives
- site visits to the lease

Consolidated Metis Locals

Project updates and other meetings continue with Metis Locals of the Wood Buffalo Region, with an emphasis on discussing potential business opportunities.

Chipewyan Prairie First Nation

Meetings continue and include project updates and discussions about potential business opportunities with local entrepreneurs, as well as site visits to the lease.

Fort McMurray First Nation

Project updates and discussions about potential business opportunities continue. A community meeting was held on June 26.

Athabasca Tribal Council

Work continues at several levels with the Athabasca Tribal Council (ATC). Recently, the First Nations' chiefs and industry senior management met to discuss concerns from the perspective of the First Nations. As a result, the ATC and industry have agreed to work together to supplement the activities of the Regional Infrastructure Working Group (RIWG). Education and infrastructure were identified as first priorities for the ATC and industry. Shell also sponsored and participated in the ATC Regional Education Conference on March 5 and 6.

Cree Burn Lake Preservation Society

Shell supports the nomination of a historical site in the vicinity of Cree Burn Lake (also known as Isadore's Lake) and the protection of this site from

Cree Burn Lake Preservation Society (cont'd)

development. Shell will not be developing in this area. The site is currently under protective notation by the Alberta Government. Shell has facilitated meetings with Alberta Community Development, Syncrude and the Cree Burn Lake Preservation Society concerning site boundary definition. Shell has also facilitated consultation between the Cree Burn Lake Preservation Society and the Fort McKay community.

Regional Municipality of Wood Buffalo

The multi-firm, multi-project model of oil sands development in the Wood Buffalo region has necessitated increased cooperation between developers and the municipality. The Regional Infrastructure Working Group (RIWG) is a municipally driven joint committee that ensures all stakeholders are involved in identifying and addressing cumulative infrastructure impacts. Shell will continue its active participation in the RIWG.

Current RIWG committees include:

- Communications
- Education and Jobs
- Regional Communities
- Social Housing
- Taxation
- Transportation

These committees have determined:

- population impacts
- infrastructure needs, including facilities, emergency services and regional community services
- social housing requirements

The committees have also:

- recommended transportation projects
- anticipated direct employment demands for oil sands industry development

Work continues at the committee level to ensure that all issues continue to be addressed on a cooperative and regional basis.

Mobil

On March 25, 1998, Mobil Oil Canada Properties filed a Statement of Concern with the EUB and AEP. The basis of the concern was that there were a number of cooperative mine planning and infrastructure issues that Mobil viewed as being

Mobil (cont'd)

outstanding. Mobil believed that if these issues were left unresolved, they could impede the future development of its Kearl Oil Sands Mine Project.

Shell and Mobil representatives have met on a number of occasions over the last several months. Many of Mobil's areas of interest relate to the future development of the eastern portion of Lease 13. Although Shell's Muskeg River Mine application relates solely to the development of the western portion of Lease 13, Shell has been working to understand and resolve the issues raised by Mobil in the interest of supporting Mobil in advancing its Kearl Oil Sands Mine development planning. Shell is confident that a collaborative and supportive understanding with Mobil can be reached.

PURPOSE

Table 5-1 summarizes the activities undertaken with stakeholders since the application was filed.

Table 5-1: Stakeholder Consultations

Date	Activity	Stakeholder
January 1998		
9	Meeting to represent Shell at Fort McMurray First Nation Grand Opening (Gregoire Lake).	Fort McMurray First Nation
16	Meeting to provide a project update and to discuss employment projections and upcoming economic workshop.	Athabasca Tribal Council (ATC) Economic Development
16	Meeting to review proposal to help coordinate Shell's consultation plan.	Metis Corp
20	Meeting to update participant status and discuss issues regarding housing and camps.	RIWG
20	Meeting to discuss geotechnical program for Clearwater River crossing.	Alberta Land and Forest Services
20	Meeting to update Shell Oil Sands developments, and receive feedback.	CEAA
22	Meeting to assess 1997 accomplishments, discuss 1998 mandate for the Shell–McKay Application Review Team.	Fort McKay First Nation, Fort McKay Metis Local 122
26	Meeting to provide a project update.	Consolidated Metis Locals (CMLs)
27	Meeting to discuss group strategies toward employment issues.	RIWG Education and Jobs Subcommittee
29	Economic Development Workshop to present a project update and to respond to local concerns.	Wood Buffalo aboriginal businesses, ATC
30	Meeting to respond to questions regarding employment, application review, education, and contract opportunities.	Fort McMurray First Nation
30	Meeting to present project update and discuss common issues and concerns.	ATC

Table 5-1: Stakeholder Consultations (cont'd)

Date	Activity	Stakeholder
February 1998		
16	Meeting to discuss Clearwater crossing, potential impact on traditional lands, and relations with trappers.	Fort McMurray First Nation
24	Meeting to discuss potential cooperation possibilities.	Mobil
26	Meeting to discuss land availability and housing planning and funding.	Mayor's Housing Stakeholder Task Force
March 1998		
3	Meeting to review pilot plans and discuss employment methods for Shell and contractors.	CML of the Wood Buffalo Region Employment Office
3	Meeting to review plans for upcoming education workshop and to discuss education plans and funding.	ATC
3	Meeting to discuss 10-year job estimates and education requirements.	RIWG (Education and Jobs Subcommittee)
3	Meeting to provide project update and discuss concerns.	Chipewyan Prairie Dene First Nation
9	Meeting to discuss Highway 63 traffic, feasibility of a new highway and potential financing options.	RIWG Transportation Subcommittee
12	Meeting to discuss review of EIA and SEIA.	Athabasca Chipewyan First Nation
12	Meeting to discuss education concerns of Fort McKay.	Fort McKay Education Committee
12	Meeting to review project status, discuss partnership possibilities and student contact.	Fort McMurray Composite High School
12	Meeting to review project status and future employment possibilities.	Fort McMurray First Nation Upgrading Program
12	Meeting to provide a general pipeline overview and to discuss cooperation.	Mobil
12 and 13	Workshop on Environmental Management in Fort McMurray	Athabasca Oil Sands CEAA Working Group
16	Meeting to review the Oil Sands Environmental Coalition's (OSEC) list of issues and statement of concern filed with AEP	OSEC
18	Meeting to discuss company updates, CEAA initiative, financial institutes, taxation, trapper compensation, development permits, ATC updates.	RIWG industry participants

Table 5-1: Stakeholder Consultations (cont'd)

Date	Activity	Stakeholder
March 1998 (cont'd)		
20	Meetings to introduce Vertex (pilot plant construction firm) to area employment offices.	Wood Buffalo Regional Municipality (WBRM), ATC, CML, and Fort McKay
25	Meeting to present overview of Shell and BHP approach to lease boundary management.	Mobil
25	Meeting with technical specialists to discuss preliminary questions on mine application and EIA.	AEP
25	RAQCC meeting at Fort McKay	RAQCC
26	Meeting to provide project update, discuss Good Neighbour Policy, education, employment and application review.	Mikisew Cree First Nation
26	Meeting to discuss project update and statement of concern.	Fort Chipewyan CML 124
27	Meeting to review application review process, provide a project update, and to receive presentation from Cree Burn Lake Preservation Society.	Leadership of the Fort McKay First Nation and Metis Local 122, elders, representatives from the community and Fort McKay Environmental Services
30	Meeting to discuss bidding of pilot work, project update and EIA review.	Athabasca Chipewyan First Nation
30	Meeting to provide a project update and to discuss the hiring process and required education.	Keyano College
April 1998		
1	Meeting with Fort McKay Industry Relations Corporation (IRC) to determine review and resolution process for Fort McKay's socio-economic concerns.	Fort McKay First Nation, Metis, elders, community liaison
2	Meeting to discuss the tailings settling pond and camp facility.	Denman Industrial
2	Meeting to discuss mine boundaries, surface resources, cooperation, federal scope, schedule and noise.	EUB
3	Meeting to discuss and resolve Mobil's issues with Shell's application.	Mobil
3	Meeting to discuss mine application, EIA feedback, and regulatory scheduling.	AEP and EUB
8	Meeting of Shell–IRC Working Group to continue identifying, reviewing and resolving socio-economic concerns.	Fort McKay First Nation, Metis and elders

Table 5-1: Stakeholder Consultations (cont'd)

Date	Activity	Stakeholder
April 1998 (cont'd)		
8	Meeting to review staffing plans for pilot, mine, extraction, construction and operations.	Fort Chipewyan Employment Office
8	Meeting to provide project update, outline regulatory process, and discuss funding for SEIA.	Fort Chipewyan Metis
14	Meeting to discuss Environmental Youth Awareness Program.	Wood Buffalo Youth Association
14	Meeting with Acting Director to discuss roles and services of ATC.	Athabasca Tribal Council
15	Meeting with pilot plant staff to review contracting process and upcoming construction schedule.	Local Fort McKay and Fort Chipewyan contractors
15	Meeting to provide a project update and to discuss contracting process and future community meetings.	Chipewyan Prairie Dene First Nation
15	Meeting of Shell–IRC Working Group to discuss concerns about traditional land use and retention of culture.	Fort McKay First Nation, Metis and elders
15	Meeting to discuss Department of Fisheries and Oceans (DFO) concerns about bridge crossing, end-pit lake drainage, water intake and quality.	DFO, CEAA, AEP
22	Pilot plant site visit to discuss possible contract opportunities with Athabasca Chipewyan First Nation businesses.	Athabasca Chipewyan First Nation businesses
23	Meeting to discuss Fort McKay trapper policy.	Fort McKay First Nation
23	Meeting of Shell–IRC Working Group to discuss community input into potential socio-economic mitigation.	Fort McKay First Nation, Metis and elders, health and wellness representatives.
29	Meeting to respond to Mobil's letters and statements of concern.	Mobil
May 1998		
6	Meeting to discuss possible partnerships and business opportunities associated with the Muskeg River Mine Project.	Fort McMurray First Nation
7	Workshop on Economics of Staying in School (Junior Achievement).	Fort McMurray School District, Athabasca Delta Community School
8	Meeting with business development staff to discuss application review process and potential funding, and process for organizing a community meeting to provide a project update and solicit community input.	Chipewyan Prairie Dene First Nation

Table 5-1: Stakeholder Consultations (cont'd)

Date	Activity	Stakeholder
May 1998 (cont'd)		
13	Workshop on contracting presented to Fort McKay entrepreneurs, including opportunity for entrepreneurs to identify concerns and develop possible solutions.	Fort McKay business community
13	Meeting to discuss boundaries of historical site at Cree Burn Lake.	Alberta Community Development
15	Meeting to review regulatory process, identify Shell support for community key areas of concern, update community needs.	Leadership of the Fort McKay First Nation and Metis Local, elders, community agencies and IRC Working Group
20	Meeting to discuss First Nation concerns about education, infrastructure, and the regulatory process.	ATC, industry senior management
21	Meeting to be introduced to new president.	Anzac Metis Local 334
22	Meeting to review committee work on future job and training requirements.	RIWG (Education and Jobs Subcommittee)
22	Meeting to discuss pilot plant status and contracts, SEIA and EIA progress, and education alternatives to Keyano.	Athabasca Chipewyan First Nation
25	Meeting to discuss community expectations regarding economic and business development in Fort McKay.	IRC and local business representatives
June 1998		
3	Meeting to review results of the Environmental Management Workshop and set future action plan.	Athabasca Oil Sands CEAA Working Group
11	Meeting with leadership and staff to discuss the contracting process.	Fort McKay Metis Local 122
11	Meeting of IRC and Shell Working Group to continue discussions on key concern areas.	IRC representatives, elders, councillors and health and wellness team representative
11	Meeting to discuss upcoming work and potential trapper impact.	IRC trapper representatives
12	Meeting with society president to tour new community daycare centre and to discuss future community plans.	Mothers of McKay Society
12	Meeting with principal to discuss potential school and education partnership.	Fort McKay School – Northlands School Division

Table 5-1: Stakeholder Consultations (cont'd)

Date	Activity	Stakeholder
June 1998 (cont'd)		
18	Meeting with leadership to review progress and plans for key concern areas.	Fort McKay First Nation and Fort McKay Metis Local 122
19	Meeting to review and discuss comments on the Muskeg River Mine application for approval.	Environment Canada

APPROVAL UPDATE

PURPOSE

Shell is seeking approvals from AEP under the *Environmental Protection and Enhancement Act.* (EPEA) and the *Water Resources Act* for various activities associated with the Muskeg River Mine Project. The activities are described in Volume 1 of the application for approval. However, some of the activities were inadvertently left out of the summary lists of approvals in:

- Volume 1, Section 1.6 and Section 16.1
- EIA Volume 2, Section A4.2.2

Table 1-1: Required Regulatory Approvals in Section 1.6 of Volume 1 has been revised to add the Class 2 landfill to the list of required approvals. The revised table is shown in Table 6-1.

Table 6-1: Required Regulatory Approvals

Approval	Legislation	Date Required	Agency
Oil Sands Approval	Oil Sands Conservation Act	December 1998	EUB
Industrial System Designation	Electrical Utilities Act	December 1998	EUB
Water Pipeline Approval	Pipeline Act	June 1999	AEP
Class 2 Landfill	Alberta Environmental Protection and Enhancement Act (EPEA)	December 1998	AEP
10 Year Approval	Alberta Environmental Protection and Enhancement Act	December 1998	AEP
Permit to Divert and Use Water	Water Resources Act	December 1998	AEP
Tailings Settling Ponds and In-Pit Dykes	Water Resources Act and EPEA	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 Protection	January 2000	Industry Canada
River Crossing	Navigable Waters Protection Act	December 1998	Coast Guard
Water Intake	Navigable Waters Protection 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

WATER RESOURCES ACT APPROVALS

Fenceline Approval

Shell is applying for a fenceline approval from the Water Resources Administration Division of AEP for the diversion, impoundment and use of surface waters and groundwater, as described in its application for approval. Under Section 11.1 of the *Water Resources Act*, each of the activities described in the application requires that an application be made to AEP and that subsequently a licence, approval or permit be issued. All of these activities are described in the application for approval that Shell submitted in December 1997 and clarified in this supplementary filing.

Figure 6-1 indicates the proposed area within which a fenceline approval would apply. These boundaries are not intended to establish the limit of activities for the Muskeg River Mine. Activities within the area would be covered by the fenceline approval, while the established licensing and approval process would continue to be followed for activities taking place outside the area.

The activities to be carried out under a fenceline approval include:

- impoundment of water for process and other uses
- surface aquifer and muskeg drainage
- basal aquifer depressurization
- surface drainage control

A fenceline approval would streamline the approval requirements for work performed at the Muskeg River Mine. Shell would still be responsible for the time and manner in which water is diverted or released, as well as any impacts that might result, as required under the Act. The schedule of water management activities for the life of the project, including the first 10 years, is shown in Volume 1, Section 8.2, Table 8-1 in the application. The water balance analysis for average conditions for the life of the project, including the first 10 years, is summarized in Volume 1, Section 8.2, Table 8-3 of the application.

Groundwater and Fenceline Permits

The list of approvals under the *Water Resources Act* in Volume 1, Section 16.1, page 16-1 should be revised to include two permits, i.e.:

- a permit for the withdrawal and diversion of groundwater for potable water use

- a fenceline permit for all other water related activities described in the application

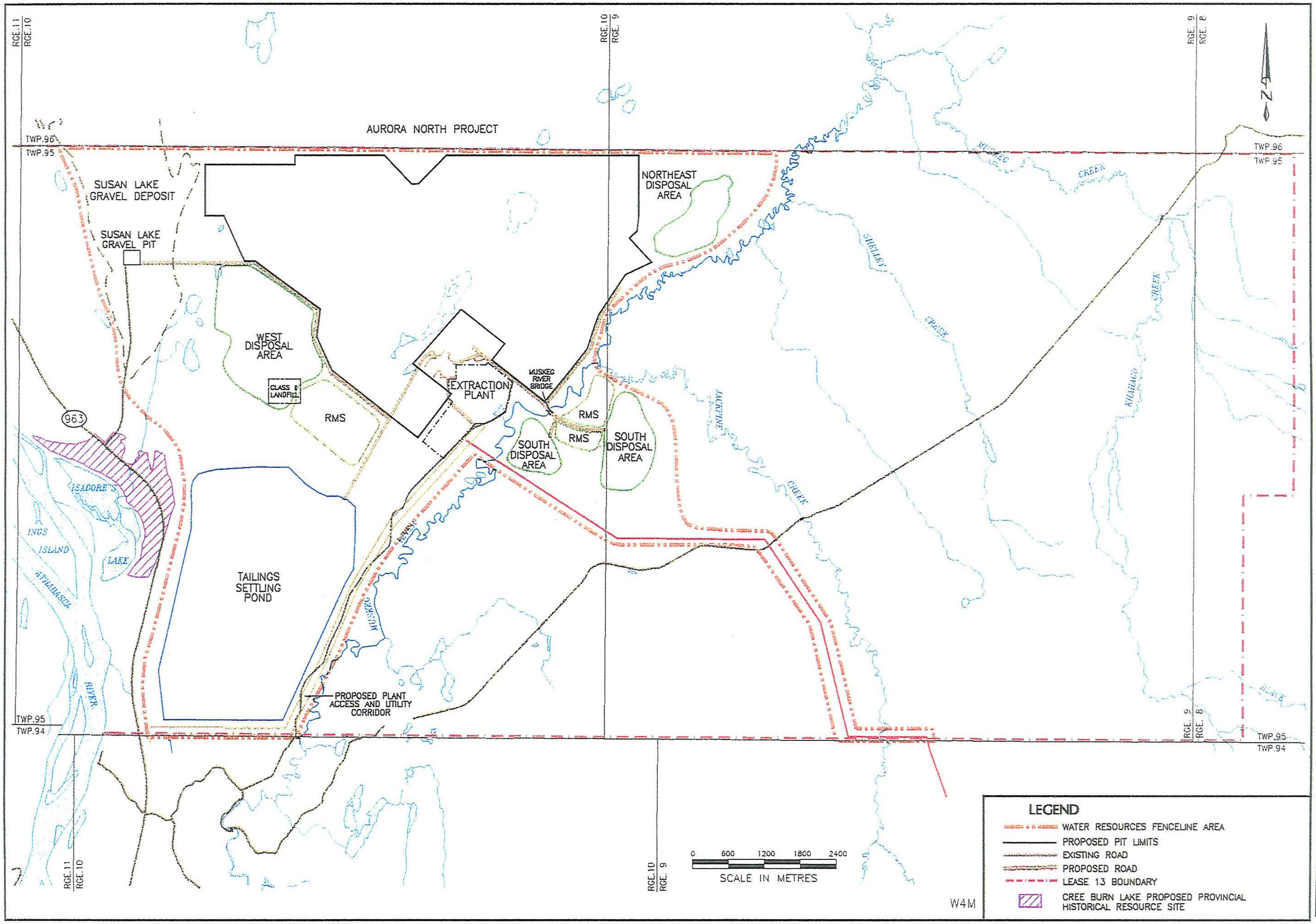


Figure 6-1: Muskeg River Mine Project Fenceline Boundary

Clarification of Previously Requested Approvals

The first two bullets of the list of approvals under the *Water Resources Act* in Volume 1, Section 16.1, page 16-1 should be revised to read:

- withdrawal and diversion of surface water and groundwater for *process water and other uses*

- impoundment of surface water and groundwater for process water *and other uses, including the tailings settling ponds and in-pit dykes*

Volume 1, Section 8.3, page 8-21 described the potable water treatment plant and the water well that will be drilled in the Quaternary aquifer to provide water for potable and other uses during construction. Shell has received authorization to conduct exploration for groundwater between depths of 18.3 and 21.3 m on LSD 06-02-095-10-W4 (Exploration Permit pursuant to the Water Resources Act File: 60376) for a maximum estimated requirement of 14 m^3/h. If the well proves to be a sustainable source, it will be used for culinary and consumptive purposes during operations.

Project water use requirements are discussed in Volume 1, Section 8.3, page 8-19. In addition to water for processing needs, these requirements include water for:

- fire protection
- vehicle and plant cleaning
- culinary and consumptive uses
- boiler feed water
- equipment gland water

The EIA, Volume 2, Section A4.2.2, page A-6, fifth paragraph, should be corrected to read:

Shell also requests AEP approval, under Section 11.1 of the Water Resources Act, for the collection and diversion of ground and surface waters, as described in Volume 1, Section 16, including:

- *diversion and impoundment of surface and groundwater for process water, potable water and water for other uses*

- diversion of natural surface waters around or away from the lease area

- muskeg dewatering

- process water ditching

- granular resource dewatering

- mine depressurization

Clarification of Previously Requested Approvals (cont'd)

- *the Muskeg River crossing*

- *a fenceline permit for all other water-related activities described in the application*

For the conceptual design of the Muskeg River crossing, see Section 3.5.

EPEA APPROVALS

Shell also requests AEP approval, under the *Environmental Protection and Enhancement Act*, for the:

- Class 2 Landfill (see Section 6.2)
- Conservation and Reclamation Plan

Conservation and Reclamation Plan

In response to concerns raised about the potential effects of the end-pit lake release water on fish habitat in the Muskeg River, Shell has modified the proposed methods of discharge from the end-pit lake (see Section 7.1). Details of the mitigation and monitoring program specific to the end-pit lake discharge are discussed in Section 7.2, including:

- volume control
- temporary diversion to the Athabasca River
- additional options to further improve the quality of the release water

The potential effects of diverting end-pit lake water to the Athabasca River were assessed through modeling. The results indicate no detrimental effect on water quality or on fish.

Section 3.6 provides updated mine development and reclamation progression plans that reflect minor changes to the northeast and south disposal areas.

PURPOSE

A need for an on-site Class 2 landfill for disposal of non-dangerous wastes was identified during waste management planning for the Muskeg River Mine. The landfill will be designed to meet the standard required by EUB Guide 58 (1996). The landfill will provide a technically reliable and cost-effective, long-term strategy for disposing of waste materials generated at the mine.

SOURCES OF WASTE

Most mine waste streams will be recycled or disposed of off-site by licensed disposal companies. However, some waste cannot be recycled and will be disposed of at the landfill to be developed at the mine site. Such waste streams include:

- sanitary sewage screenings
- non-recyclable solid wastes
- filter elements, such as air and water
- filter sludge
- process strainers
- screened solids from pipes and equipment
- empty crushed and rinsed chemical drums

All materials will comply with Class 2 non-dangerous oilfield wastes as per EUB Guide 58 (1996). The volume of waste material requiring disposal in the landfill is estimated to be 3,100 m^3/a.

SITE SELECTION

The proposed site for the landfill is southwest of the open-pit mining area, within the west overburden storage area. This site is:

- in an area with adequate land available
- contained in an area already disturbed by mine activities
- 5 km away from the mine infrastructure
- not a wetland or critical wildlife habitat

SITE SELECTION (cont'd)

- not over a buried channel aquifer or in the recharge zone of an unconfined aquifer
- not overlying an aquifer producing 9 L/min

By constructing the landfill in conjunction with the overburden storage, it will be located in an easily accessible and controlled area, as well as being elevated above the groundwater table.

TOPOGRAPHY AND DRAINAGE

By locating the landfill within the overburden stockpile, the topography and drainage of the site can be established to suit the needs of the landfill. The landfill site will be contoured and roughly graded as designed, using stockpiled outwash sands and gravels, clay tills, and lean oil sands contained in the overburden stockpile. After the site has been rough graded, the subgrade will be compacted to form a firm base for construction and liner installation. The perimeter will be graded to direct surface water runoff away from the landfill area. Also, because the landfill will be within the overburden stockpile area, it will be within an area of controlled drainage.

SITE GEOLOGY

The overburden geology at the landfill site was interpreted from borehole log information. The soil profile consists of muskeg on top of outwash sand, on top of oil sands. Muskeg is intermittent and varies in thickness between 0 to 2 m. The outwash sands, which are common over much of the mine site, are also intermittent and between 1 and 5 m thick. The sand is fine grained, often loose, with trace to little fines. Beneath this overburden are oil sands, the top of which lies 1 to 5 m below the topography, fine grained with a little silt and clay. The oil sands are medium to very dense, increasing with depth. The water table is perched on top of the low permeability oil sands, which act as an aquitard, preventing the downward migration of potential contamination from the surface.

SITE HYDROGEOLOGY

Although the landfill will be constructed within the overburden stockpile, a-site specific investigation will be performed as required by Section 15.5 1. (a) of EUB Guide 58. This detailed investigation will validate the site geology as well as the hydrogeological conditions, such as:

- depth to groundwater
- direction of groundwater flow
- hydraulic conductivity of the surficial soils
- existing groundwater chemistry

SITE HYDROGEOLOGY (cont'd)

The existing site conditions are as follows:

- the groundwater table overlies oil sands, at a depth of 1 to 5 m below ground surface
- surficial soils consist predominantly of outwash sands, hydraulic conductivity 10^{-4} to 10^{-6} m/s
- groundwater flow direction is to the south, either to the southeast to Muskeg River or to the southwest to the Athabasca River
- groundwater chemistry is a calcium–magnesium bicarbonate type, with mineralization less than 1,000 mg/L

The site has two significant advantages concerning groundwater:

- by constructing the landfill within the overburden stockpile it will be well above the highest seasonal water table
- the underlying oil sands will act as an aquitard, preventing the downward migration of any potential contamination in the unlikely event of seepage

DESIGN

Criteria for designing the Class 2 landfill are based on EUB Guide 58 (1996).

The landfill will be constructed within the west disposal area overburden. The landfill will be lined with a synthetic liner and will include:

- leachate collection
- leak detection
- a gas venting system

A firm subgrade will be prepared by compacting select stockpiled overburden.

A preliminary design plan is shown in Figure 6-2 A cross-section of the landfill is shown in Figure 6-3.

A surface water management plan will be in place to control run-on and runoff for the 1 in 25 year storm event and will be integrated with the mine runoff control system.

The final design will be completed before construction of the landfill begins. The landfill will be constructed and filled in a cellular fashion, expanding as required during the life of the mine. The first cell will be constructed to last five years, with an approximate volume of 16,000 m^3.

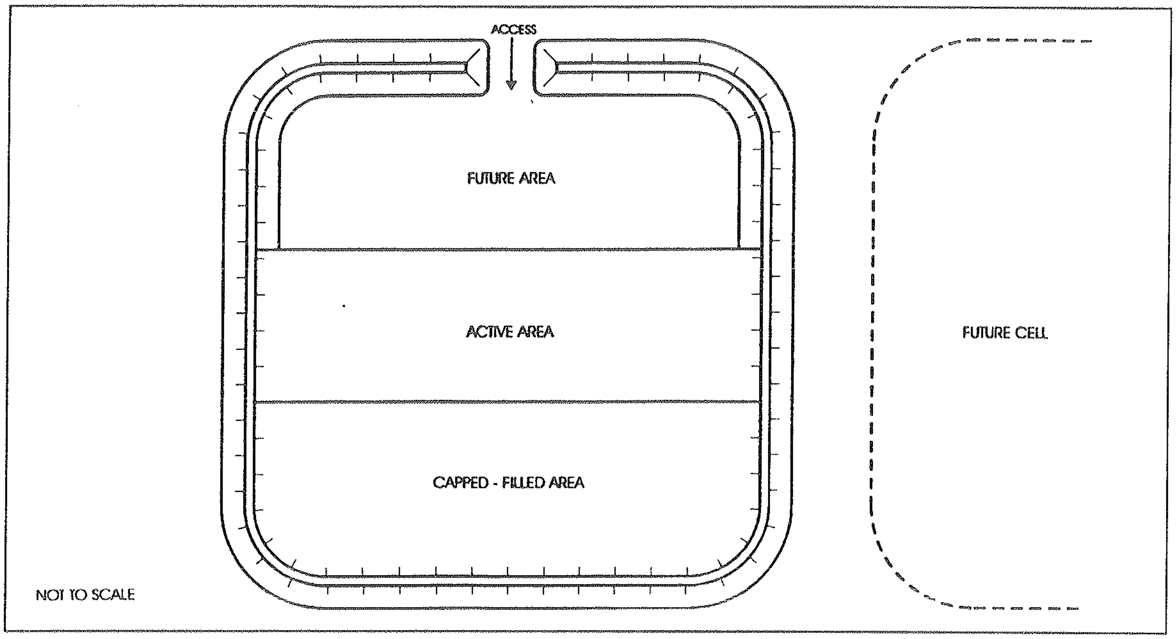


Figure 6-2: Preliminary Landfill Design Plan

WATER MANAGEMENT

The leachate collection system for the landfill will consist of a sand drainage layer over the synthetic liner. Perforated collection pipes will be incorporated into the drainage layer to convey water to a central collection sump. Water collected from the leachate collection sump will be sampled and either released or disposed of, depending on its quality.

A drainage net will be installed beneath the synthetic liner. The drainage layer will lead to a monitoring well, downgradient of the landfill. Any water that accumulates in the monitoring well will be sampled and monitored in accordance with the Action Leakage Rate Guideline (AEP, 1996). As water other than seepage from the landfill could migrate into the leak detection layer, the potential for leakage through the primary liner will be assessed by completing chemical analyses on water collected from the monitoring well. Sampling (if water is present) and analyses will be completed twice annually.

The final cap will be a minimum 0.6 m thick layer of clay soil, compacted to achieve a maximum permeability of 1×10^{-7} m/s, as measured by a laboratory falling head permeability test. Alternatively, the cap may be constructed using a synthetic liner. The protective buffer layer for the cap, including a subsoil and topsoil layer, will be incorporated into the final cap, consistent with the requirements of EUB Guide 58.

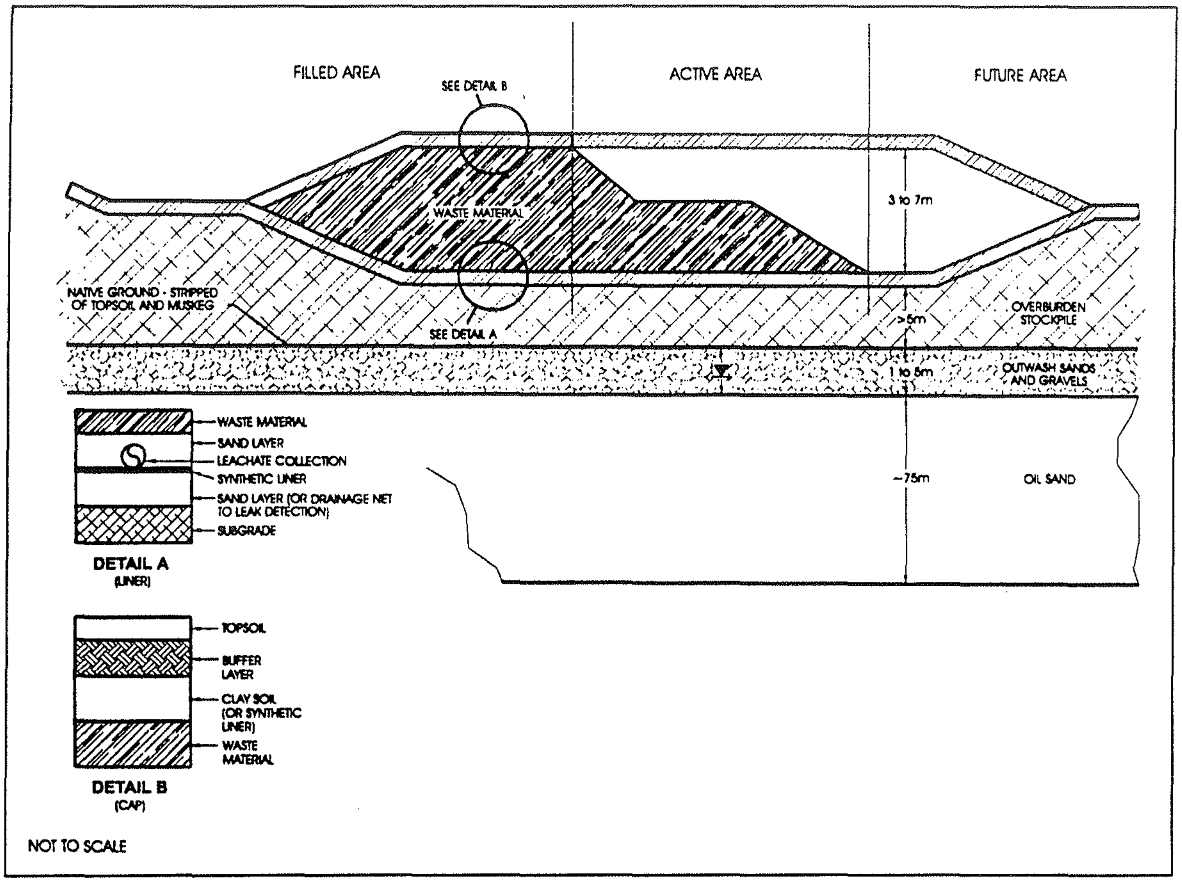


Figure 6-3: Landfill Cross-Section

OPERATION

The landfill will be used to contain wastes generated by the Muskeg River Mine during start up and operation that are classified as non-dangerous oilfield waste, as defined in EUB Guide 58. In addition, the acceptance criteria for non-hazardous wastes, as specified in the *Alberta User Guide for Waste Managers* (AEP, 1996), will be applied.

No materials generated from outside the mine site will be accepted for disposal. All materials to be accepted will be the property or responsibility of the mine operator.

The landfill will be operated in accordance with the requirements of EUB Guide 58. Shell will develop an operations manual for the landfill. The operation will be based on:

- operating the landfill as a Class 2 facility
- managing materials to prevent spills and leaks of contaminated material
- measuring and reporting material volumes to the EUB

OPERATION (cont'd)

- implementing air quality surveys as a health and safety precaution
- having a qualified individual direct construction and operations activities
- completing field testing to verify that construction is in accordance with design specifications
- preventing public access to the landfill site
- completing operations in accordance with a site-specific health and safety plan

Quality assurance and quality control (QA and QC) programs will be implemented to ensure that the landfill construction is completed in accordance with the construction specifications. The following QA and QC measures will be documented and implemented:

- designing according to recognized civil and geotechnical engineering practices
- developing construction specifications to augment design drawings and to ensure proper installation
- testing soil components to establish grain size distribution, moisture content, Atterberg limits, hydraulic conductivity and in-place density
- inspecting and testing to ensure that the synthetic liner and associated piping are installed according to specifications and manufacturers' instructions

MONITORING

A groundwater monitoring system of four to eight monitoring wells will be installed around the perimeter of the landfill. The location of the monitoring wells will take into account the development of the mine pit, which will be the local discharge point for groundwater during most of the active life of the landfill. As much as possible, the piezometers from the initial groundwater site investigation will be retained for use as part of the groundwater monitoring network. Analyses from the initial groundwater investigation, as well as samples taken before the beginning of landfill operations, will verify initial groundwater conditions, such as:

- water table overlying oil sands
- Ca-Mg HCO_3 type

The piezometers will be monitored twice a year during landfill operations.

POST-CLOSURE PROGRAM

The program for post-closure care is designed to verify and maintain the integrity of the closure using regular inspections, maintenance and monitoring, including inspecting:

- the top surface of the capped areas to identify areas of potential erosion, loss or lack of vegetation, or indications of subsidence
- stormwater drainage patterns, to confirm flow directions and identify areas of erosion, sedimentation, subsidence and flow impediments
- the water collection system, to verify operation in accordance with design requirements and to identify any possible areas of sediment accumulation or biological growth

The closed and capped areas will be inspected regularly according to the post-closure care schedule (see Table 6-2). Inspection, maintenance and monitoring activities will be performed quarterly in the first two years and annually thereafter, until the post-closure care program is complete. Specific inspections and monitoring rounds will also be completed after major storm events. Additional rounds will also be completed if any unusual conditions are observed.

The groundwater monitoring program will be continued as specified, although sampling frequency will be reduced to once a year during the post-closure program. Monitoring reports will be submitted annually.

Vegetation over the capped landfill will be maintained according to the mine reclamation plan to prevent erosion and sediment transport. This will include re-establishing vegetation in areas that have been eroded or where vegetation has not been maintained, and fertilizing as required to support permanent vegetative growth. Collection systems will be cleaned, as required.

Table 6-2: Post-Closure Care Schedule

Item	Frequency	Concerns
Cover inspection	Quarterly for two years; annually thereafter	Erosion, sedimentation, subsidence, drainage
Cover survey	Quarterly for two years; annually thereafter	Subsidence
Cover vegetation	Quarterly	General maintenance
Area drainage	Quarterly for two years; annually thereafter	Drainage, sedimentation erosion, subsidence
Water collection	Quarterly for two years; annually thereafter	Operation, volumes, potential clogging, wear
Groundwater	Annually	Water quality

MANAGEMENT OF END-PIT LAKE DISCHARGE TO THE MUSKEG AND ATHABASCA RIVERS

The application and EIA identified all discharges from the end-pit lake that were to be released to the Muskeg River. However, concerns have been raised about the potential effects of the end-pit lake release water on fish habitat in the Muskeg River because of potential changes in flow, temperature, and water quality. Therefore, Shell has modified the proposed method of discharge from the end-pit lake. The discharge will be diverted, to the extent necessary to prevent any impacts in the Muskeg River, directly to the Athabasca River during periods of greatest end-pit lake discharge, and during sensitive fish periods in the Muskeg River. The flow, quality and temperature at the discharge points from the end-pit lake and in the Muskeg River will be monitored. With these modifications, Shell will be able to regulate the releases from the end-pit lake to the Muskeg River, to ensure no adverse effects on fish habitat, fish and other aquatic resources. The releases from the end-pit lake to the Muskeg River can be reduced to "zero discharge", if necessary.

In addition to this mitigation and monitoring program, options to further improve the quality of the release water from the end-pit lake will be examined during the project design phase. These options include adding wetlands to the end-pit lake outlet channel, adding Athabasca River water to the end-pit lake, and adding nutrients to the end-pit lake to promote biological activity and higher levels of bio-remediation. In addition, during operations, Shell will continue to review the results of research and monitoring programs on degradation rates, such as the Base Mine Lake (Syncrude's water-capped lake at the Mildred Lake facility) project, and other operators' consolidated or composite tailings (CT) pilot programs.

This update includes details on:

- the mitigation and monitoring program, including details of the design and operation of the program

- end-pit lake releases to the Muskeg River, including a more extensive assessment of the potential effects of the end-pit lake releases, with and without mitigation, than that outlined in the EIA

Mitigation and Monitoring Program

Managing the end-pit lake will span eight years, from 2023 to 2031. The transfer of mature fine tailings (MFT) to the end-pit lake and the higher discharges from the end-pit lake to the Muskeg River would only occur for three years, i.e., 2028

Mitigation and Monitoring Program (cont'd)

to 2030. The maximum release of 1.5 m^3/s would occur in 2030. End-pit lake releases would occur only during the open water seasons, i.e., spring, summer and fall.

The mitigation and monitoring program has been designed to protect the fish resources of the Muskeg River from any adverse effects from changes in flow, temperature, and water quality. The program (see Figure 7-1), consists of:

- facilities to divert end-pit lake releases directly to the Athabasca River
- facilities to control the volume of release water from the end-pit lake to the Muskeg River
- the feedback monitoring system, which will measure potential changes in the Muskeg River from end-pit lake releases, compare these changes to set points or thresholds, and regulate flows from the end-pit lake to the Athabasca and Muskeg rivers. The feedback monitoring system will be implemented during the three years of transfer of MFT to the end-pit-lake, i.e., 2028 to 2030.

The volume of water being released to the Muskeg River will be regulated through a manually operated control structure on the outlet channel from the end-pit lake, and by either slowing the rate of transfer of MFT to the end-pit lake or temporarily diverting end-pit lake water directly to the Athabasca River. Slowing the rate of transfer of MFT to the end-pit lake will increase the retention time of water in the lake, allow for greater warming, and increase the levels of bio-degradation or sedimentation. If necessary, during sensitive periods for fish in the Muskeg River, such as spring spawning, or during the years of highest volume releases, all waters from the end-pit lake could be temporarily diverted to the Athabasca River. The potential effects of such a diversion on the water quality of the Athabasca River have been evaluated and are presented later in this section under *Potential Effects of Mitigation on Water Quality of the Athabasca River*.

It is not desirable to shift all the releases from the end-pit lake to the Athabasca River throughout the entire three-year period of MFT transfer. It would be beneficial for the Muskeg River watershed waters flowing into the end-pit lake to be returned to the Muskeg River, to maintain natural flow in this river system.

The facilities to temporarily divert water from the Muskeg River and transfer water from the end-pit lake to the Athabasca River consist of (Figure 7-1):

- a control structure on the outlet channel of the end-pit lake to regulate the release of water from the end-pit lake to the Muskeg River
- a pipeline to transfer water from the end-pit lake to the Athabasca River. The strategy is to reverse the flow through the existing pipeline that will be used during operations to transport water from the Athabasca to the plant site.

Mitigation and Monitoring Program (cont'd)

- a pumping station to be installed on the pipeline diverting water from the end-pit lake to the Athabasca River

- a monitoring station (MS4) at the pumping station to evaluate the quality, temperature and flow of water being released to the Athabasca River

Three additional monitoring stations will be part of this feedback monitoring program:

- the existing monitoring station on the Alsands drain (MS1), which is located on the outlet channel of the end-pit lake, will be maintained to monitor the water released from the end-pit lake

- two new monitoring stations (MS2 and MS3), which will be installed on the Muskeg River, one upstream and one downstream of the end-pit lake outlet to the river

The parameters that will be measured at each of the three monitoring stations include discharge, temperature, acute and chronic toxicity, total suspended solids (TSS), and metals. During the first monitoring year (2028), the first two parameters will be measured continuously and the later parameters will be measured once a month. The frequency of parameter measurements will be adjusted in the second year, depending on the results determined in the first year.

If near threshold values for flow, temperature or quality are identified during monitoring, the response time for reducing release volumes from the end-pit lake to the Muskeg River could range from two to five hours. In the unlikely event that near threshold values for toxicity are identified, response time would be longer, i.e., three to four days, because of the time required to compete toxicity laboratory tests.

The thresholds or set point criteria that could be used to identify when end-pit lake water should be diverted from the Muskeg River to the Athabasca River will be finalized through discussions with the Department of Fisheries and Oceans (DFO) and AEP. Potential set points could be based on existing standards for temperature, toxicity and TSS.

Understanding the Potential Effects of End-Pit Lake Releases on the Muskeg and Athabasca Rivers

This update contains a more detailed analysis of the potential effects of end-pit lake releases during the spring, summer and fall on the flow, temperature and water quality of the Muskeg River than that presented in the EIA. A range of effects was analyzed:

- from zero discharge to the Muskeg River, which reflects Shell's current plan to divert all the end-pit lake release waters directly to the Athabasca River during periods of high end-pit lake releases

Understanding the Potential Effects of End-Pit Lake Releases on the Muskeg and Athabasca Rivers (cont'd)

- to the hypothetical 100% discharge to the Muskeg River, which reflects the original effects identified in the EIA

The potential effects of the end-pit lake releases on the Athabasca River have also been evaluated and are discussed in this section.

Potential Effects on Flow of the Muskeg River

There is a concern that a change in flow of the Muskeg River will either reduce the availability (depth, velocity distribution) or the quality (sedimentation) of fish habitat. As it is currently Shell's intention to divert end-pit lake discharges to the Athabasca River during periods of maximum release, this concern is reduced in scale compared to the concern originally raised in the EIA.

Minor increases in flow are expected in the Muskeg River from end-pit lake releases, for both the Shell alone and the cumulative effects assessment (CEA) development scenarios. However, these increases are not expected to affect fish habitat or fish populations.

The changes in Muskeg River flow as a result of zero release, and up to the hypothetical 100% release (1.5 m^3/s) of water from the end-pit lake are illustrated in Figure 7-2. The range in the change of mean flows of the Muskeg River when the end-pit releases are either totally diverted to the Athabasca River (i.e., with mitigation) or totally diverted to the Muskeg River (hypothetical case) are:

- 0 to 10% during spring
- 0 to 15% during summer
- 0 to 18% during fall

These potential flow increases are well within the range of natural seasonal flow variability in the Muskeg River. Natural variability ranges as follows:

- May — from 0.33 to 36.7 m^3/s
- June — from 0.74 to 27.0 m^3/s
- October — from 0.42 to 21.1 m^3/s

The cumulative effects assessment scenario includes effects from:

- Aurora Mine South and North seepage
- muskeg and overburden releases
- Shell seepage

Figure 7-3 shows the change in Muskeg River flow resulting from end-pit lake releases when the cumulative effects are also considered. The range in change of mean flows of the Muskeg River when the end-pit lake releases are either totally diverted to the Athabasca River (i.e., with mitigation), or totally diverted to the Muskeg River (the without mitigation hypothetical case) are:

Potential Effects on Flow of the Muskeg River (cont'd)

- 1 to 11% during spring
- 5 to 20% during summer
- 4 to 22% during fall

These increases are not expected to affect fish habitat negatively. The potential adverse effect of increased flow is increased streamflow sediment concentrations from increased erosion. However, the magnitude of increased streamflow sediment will be small, because the Muskeg River has slow-flowing water from the shallow gradient and large floodplain (see *Potential Effects on Water Quality of the Muskeg River* later in this subject for a further discussion on TSS). This conclusion on small increase in sediment is based on monitoring observations at the Water Survey of Canada station near the mouth of the Muskeg River.

The potential changes in depth and velocity of the Muskeg River as a result of releases from the end-pit lake are not expected to affect fish or benthic invertebrates. The predicted increase in the mean open-water seasonal flow because of the hypothetical maximum release from the end-pit lake would be 19%. This translates to an increase in river depth of about 7 cm, which is about 12.5% of the natural mean flow depth during the open-water season. The increased flow would raise the mean streamflow velocity by about 4 cm/s, which would be about 6% of the natural mean flow velocity during the open-water season.

Potential Effects on Temperature of the Muskeg River

There is a concern that releases from the end-pit lake will change the water temperature and affect fish or fish habitat. As it is currently Shell's intention to divert end-pit lake discharges to the Athabasca River during periods of maximum release, this concern is reduced in scale compared to the concern originally raised in the EIA.

Effects on benthic invertebrate species composition and abundance and on fish or fish habitat are not expected because of the:

- very small changes predicted in the Muskeg River temperatures from Shell's analysis

- conservative nature of the predictions

Several conservative assumptions were used when estimating the potential changes in Muskeg River temperature from end-pit lake releases. The evaluation assumed:

- maximum end-pit lake releases

- that there would be no end-pit lake stratification. (Therefore, surface releases from the end-pit lake would likely be warmer than assumed in the evaluation.)

Potential Effects on Temperature of the Muskeg River (cont'd)

- that rapid heating of low flow outlet streams from reservoirs had been reported

- no increase in temperature of the muskeg or overburden water in sedimentation ponds or drainage channels. This assumption is relevant to the CEA development analysis.

The estimated temperatures for the end-pit lake flow and muskeg or overburden drainage waters used for predicting changes in river temperature are illustrated in Figure 7-4. The end-pit lake temperatures resemble those of large lakes, with slow warming in the spring and slow cooling in the fall. The muskeg or overburden and seepage water temperatures are assumed to be cool, in the range of 2 to 6°C, similar to shallow groundwater temperatures.

The potential changes in Muskeg River temperature for the hypothetical case, where the maximum end-pit lake releases are diverted to the Muskeg River, are illustrated by the line representing the year 2030 in Figure 7-5. The median monthly temperature would change little, with the maximum decrease of 0.8°C occurring in the summer. These temperature changes are well within the natural variability of water temperatures that occur in the Muskeg River.

The potential changes in temperature of the Muskeg River as a result of releases from the end-pit lake when the effects from the CEA scenario are included are illustrated in Figure 7-6. The graph depicts potential changes as a result of zero discharge (all waters diverted to the Athabasca River) to the hypothetical 100% discharge from the end-pit lake to the Muskeg River. The hypothetical low spring flow represents the worst case scenario.

Under the hypothetical scenario, where the end-pit lake releases are diverted to the Muskeg River, a slight cooling effect could occur in spring and summer (maximum decrease of 2.2°C under the hypothetical low spring flow) and a slight warming effect in the fall (increase of 0.5°C). Under the worst case low spring flow for the CEA, the end-pit lake would have little effect on temperature. Most of the decrease in river temperature in the spring and summer is because of the cooler seepage and muskeg or overburden releases from upstream operations, not the end-pit lake releases. These CEA scenario temperature changes are well within the natural variability of Muskeg River temperature changes.

The slight temperature reductions predicted in the Muskeg River due to the hypothetical scenario would:

- slightly improve habitat conditions for species such as Arctic grayling
- slightly reduce habitat suitability for species such as the northern pike

The optimal temperature for adult Arctic grayling reported in the literature ranges from 5 to 12°C. Optimal temperatures for pike are eggs — 6 to 16°C, juveniles — 22 to 26°C, and adults — 19 to 21°C (Ford et al, 1995). Therefore, any thermal reduction from May to September, when ambient temperatures are

Potential Effects on Temperature of the Muskeg River (cont'd)

generally about 12°C, would improve habitat suitability for grayling, but reduce suitability for pike. The optimal temperature conditions for juvenile and adult pike are generally not achieved naturally.

Concern has been raised about potential effects of temperature alteration on benthic invertebrates in the Muskeg River, caused by water discharge from the end-pit lake. Potential impacts are:

- reduced summer water temperature
- reduced diurnal fluctuation
- disruption of seasonal patterns

The effect of the end-pit lake on temperature and biological communities of the Muskeg River is analogous to the effects of reservoirs on rivers. Species richness of the benthic community is usually reduced below reservoirs because of temperature effects. However, density changes are largely a function of flow constancy (constant flow = high density and vice versa (Ward and Stanford, 1979). The end-pit lake is not expected to greatly influence flow constancy, therefore, substantial effects on density are not expected.

Most of the literature on temperature effects focuses on severe reductions (up to 20°C) in summer water temperature below deep-release reservoirs. Under such conditions, negative effects on invertebrates include slower growth, not completing life cycles, delayed or lengthened emergence periods, and reduced fecundity. This can result in a community becoming dominated by species tolerant of lower temperatures, primarily Diptera (chironomids and blackflies) (see Ward, J.V. and J.A. Stanford, 1979).

Considerably less severe reductions in water temperature (less than 3°C, even with the hypothetical maximum releases from the end-pit lake to the Muskeg River) were predicted below the end-pit lake. Hence, the severe effects on invertebrates below deep-release reservoirs cited in the literature are unlikely to occur in the Muskeg River below the end-pit lake. In addition, the Muskeg River is already dominated by chironomids (see EIA Volume 2, Section D6.3.1), which also suggests that major community changes from the predicted temperature reductions are unlikely.

The effects of reduced diurnal fluctuation have not been widely investigated. Diurnal constancy might cause reduced competitive ability in invertebrates that require a wide range of diurnal fluctuation. Therefore, it might result in the benthic community being altered (e.g., reduced diversity, greater dominance by tolerant invertebrates). The EIA did not predict diurnal constancy because:

- a large part of the flow in the Muskeg River will always be natural

- end-pit lakes will have relatively long discharge channels, which will allow the development of some diurnal fluctuation

Potential Effects on Temperature of the Muskeg River (cont'd)

For example, below a deep-release reservoir causing a maximum summer temperature decline of 8°C, a diurnal fluctuation of 6°C developed 8-9 km below the dam (Ward and Stanford, 1979). Given that the EIA predicted maximum temperature declines are less than half of this value, the length of the affected reach should be considerably shorter, potentially corresponding to the length of Shell's end-pit lake discharge channel.

Severely disturbed seasonal patterns were not predicted by the EIA. The accounts of severe effects on benthic communities in the literature focus on seasonal constancy (i.e., constant, low water temperature in all seasons). This does not apply to the Muskeg River, which might experience a small reduction in the amplitude of seasonal temperature variation.

In summary, slight reductions in summer water temperature and diurnal fluctuation and potential slight disruption of seasonal patterns because of the end-pit lake are unlikely to affect benthic invertebrate communities in the Muskeg River. The slight changes in benthic communities that might occur below the end-pit lake would not influence the availability of invertebrate food for fish. In addition, because of the conservative assumptions used in the analysis, considerable uncertainty exists about the occurrence of predicted temperature changes in the Muskeg River. Shell will monitor water temperature and benthic communities in the Muskeg River as part of the Regional Aquatic Monitoring Program (RAMP) to verify the impacts predicted in the EIA.

Daily temperature fluctuations in the Muskeg River might be slightly altered by releases from the end-pit lake, but changes are expected to be small. This is because the hypothetical maximum end-pit lake discharge forms only 10 to 18% of the flow of Muskeg River discharge. The effects of changes in diurnal temperature fluctuations on fish have not been widely investigated. Reduced competitive ability in fish species that require a wide range of diurnal fluctuation might exist, but this hypothesis has not been verified in the field.

Potential Effects on Water Quality of the Muskeg River

There is a concern that the quality of the end-pit lake release waters will reduce the quality of the Muskeg River water and adversely affect benthic invertebrates or fish resources. As Shell currently intends to divert end-pit lake discharges to the Athabasca River during periods of maximum release, this concern is reduced in scale compared to the concern originally raised in the EIA.

Based on conservative assumptions, our analysis indicates that certain substances would exceed instream water quality guidelines with increasing release volumes from the end-pit lake. However, most of the parameters are exceeded naturally and should not adversely affect fish health.

Several conservative assumptions were made when estimating the potential changes in water quality. The evaluation assumed:

- maximum end-pit lake releases

Potential Effects on Water Quality of the Muskeg River (cont'd)

- maximum values for water quality contaminants in the end-pit lake waters
- no instream chemical decay, settling or sediment partitioning

Potential changes in water quality were calculated as a result of varying release volumes from the end-pit lake, ranging from zero discharge (waters are diverted to the Athabasca River) to 100% hypothetical discharge from the end-pit lake to the Muskeg River. The results are summarized in:

- Table 7-1 (spring)
- Table 7-2 (summer)
- Table 7-3 (fall)

Seasonal changes in toxicity are illustrated in:

- Figure 7-7 (spring)
- Figure 7-8 (summer)
- Figure 7-9 (fall)

Seasonal changes in total suspended solids are illustrated in:

- Figure 7-10 (spring)
- Figure 7-11 (summer)
- Figure 7-12 (fall)

Toxicity from the end-pit lake releases are well within the acute and chronic guidelines. The maximum increase in TSS concentration is about 0.8 mg/L, which compares to a natural background level in the Muskeg River of 9.5 ml/L. This is well within the guideline that allows an increase of 10 mg/L TSS. Discharges of end-pit lake water in the spring and fall do not result in exceedances of the water quality guidelines in the Muskeg River beyond those exceedances already documented in the EIA for summer releases (see EIA, Volume 3, Tables E5-6, E5-7 and EIA Volume 4, Tables F5-3, F5-4, G5-3 and G5-4).

Potential Effects of Mitigation on Water Quality of the Athabasca River

The potential effects of directly transferring end-pit lake water to the Athabasca River were evaluated through modeling. The results indicate no detrimental effect on the quality of the river water and, therefore, no effect on fish.

Two modeling scenarios were completed:

- Scenario 1, which assumed all the end-pit lake release waters are diverted directly to the Athabasca River

Potential Effects of Mitigation on Water Quality of the Athabasca River (cont'd)

- Scenario 2, which takes into account new information about the Millennium Project i.e., reduced volumes of wastewater. This information became available after filing the Muskeg River Mine EIA.

The modeling results for Scenario 1 indicated that discharging end-pit lake water directly to the Athabasca River produced water quality concentrations in the Athabasca identical to those projected in the Muskeg River Mine EIA when water was routed through the Muskeg River. Table 7-4 presents the predicted water quality values for various substances with end-pit lake degradation. These results are illustrated on contour plots in:

- Figure 7-13 - Benzo(a)anthracene concentrations in the Athabasca River in 2030
- Figure 7-14 - Benzo(a)pyrene concentrations in the Athabasca River in 2030
- Figure 7-15 - Acute toxicity concentrations in the Athabasca River in 2030
- Figure 7-16 - Chronic toxicity concentrations in the Athabasca River in 2030

Updating the model to account for differences in the releases associated with the Millennium Project, i.e., Scenario 2, did not produce substantially different results from those already identified in the Muskeg River Mine EIA (see Table 7-5).

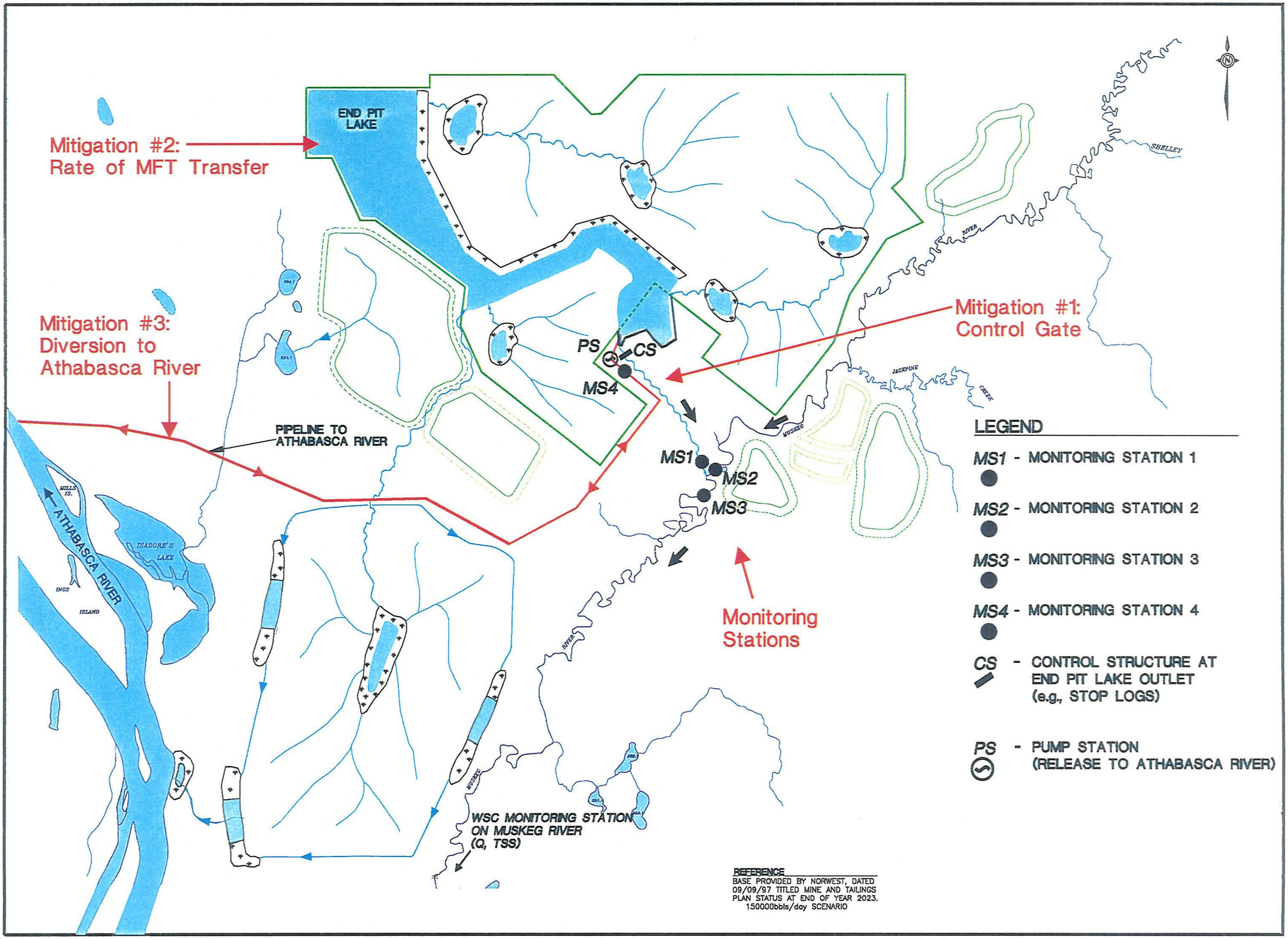


Figure 7-1: Monitoring and Response Systems

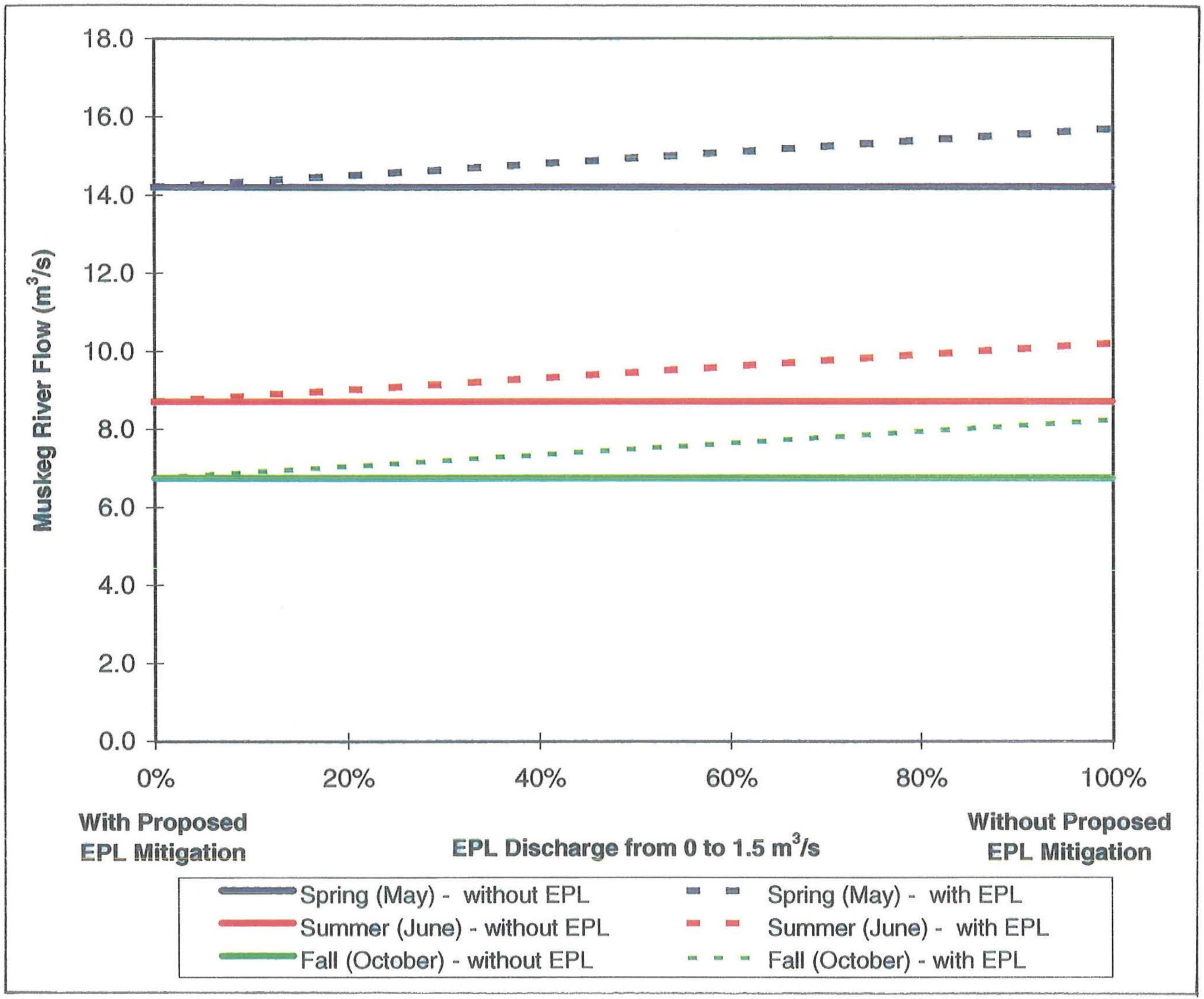


Figure 7-2: Change in Muskeg River Flow from End-Pit Lake Discharge (Shell Project Alone)

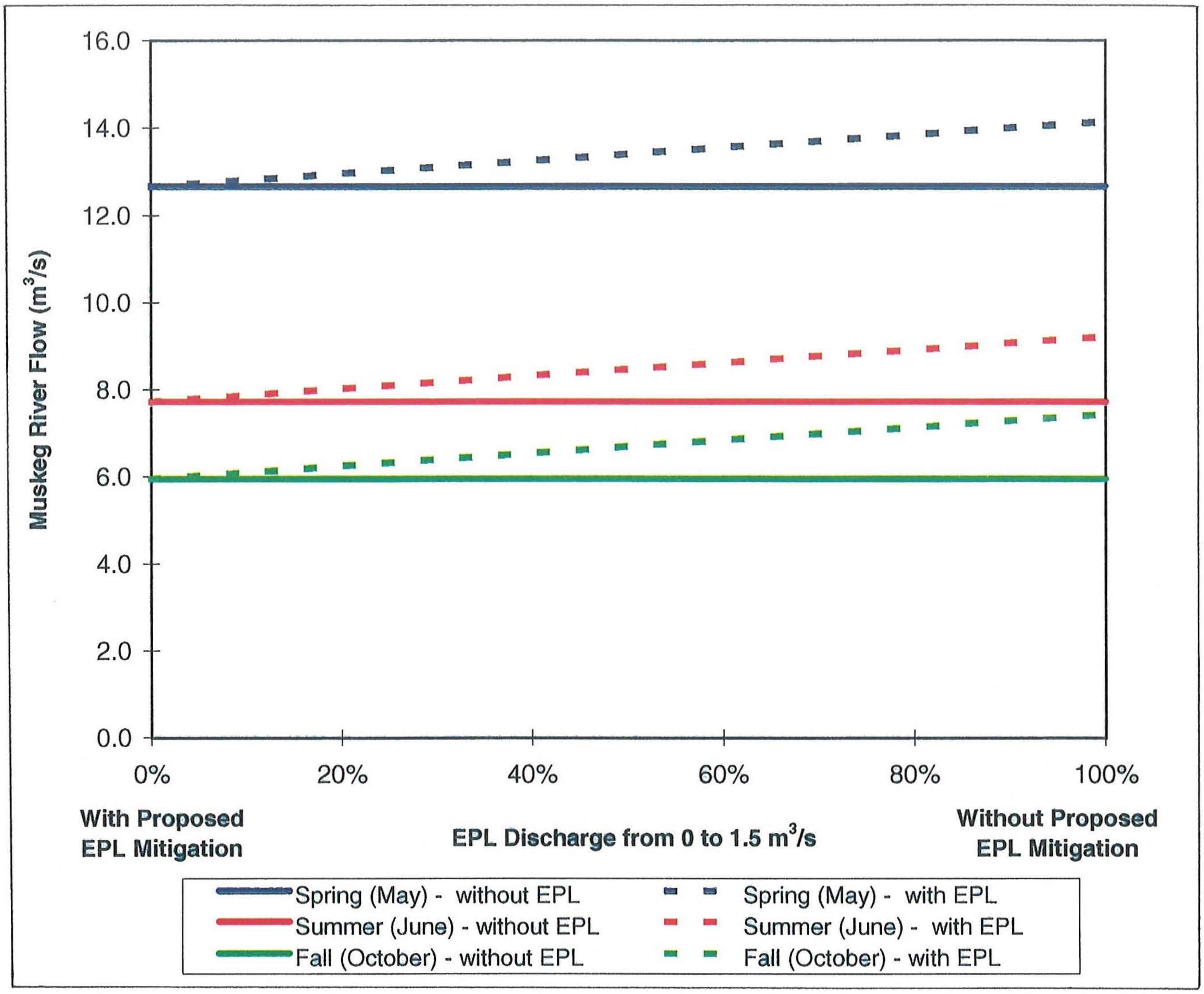


Figure 7-3: Change in Muskeg River Flow from End-Pit Lake Discharge (CEA)

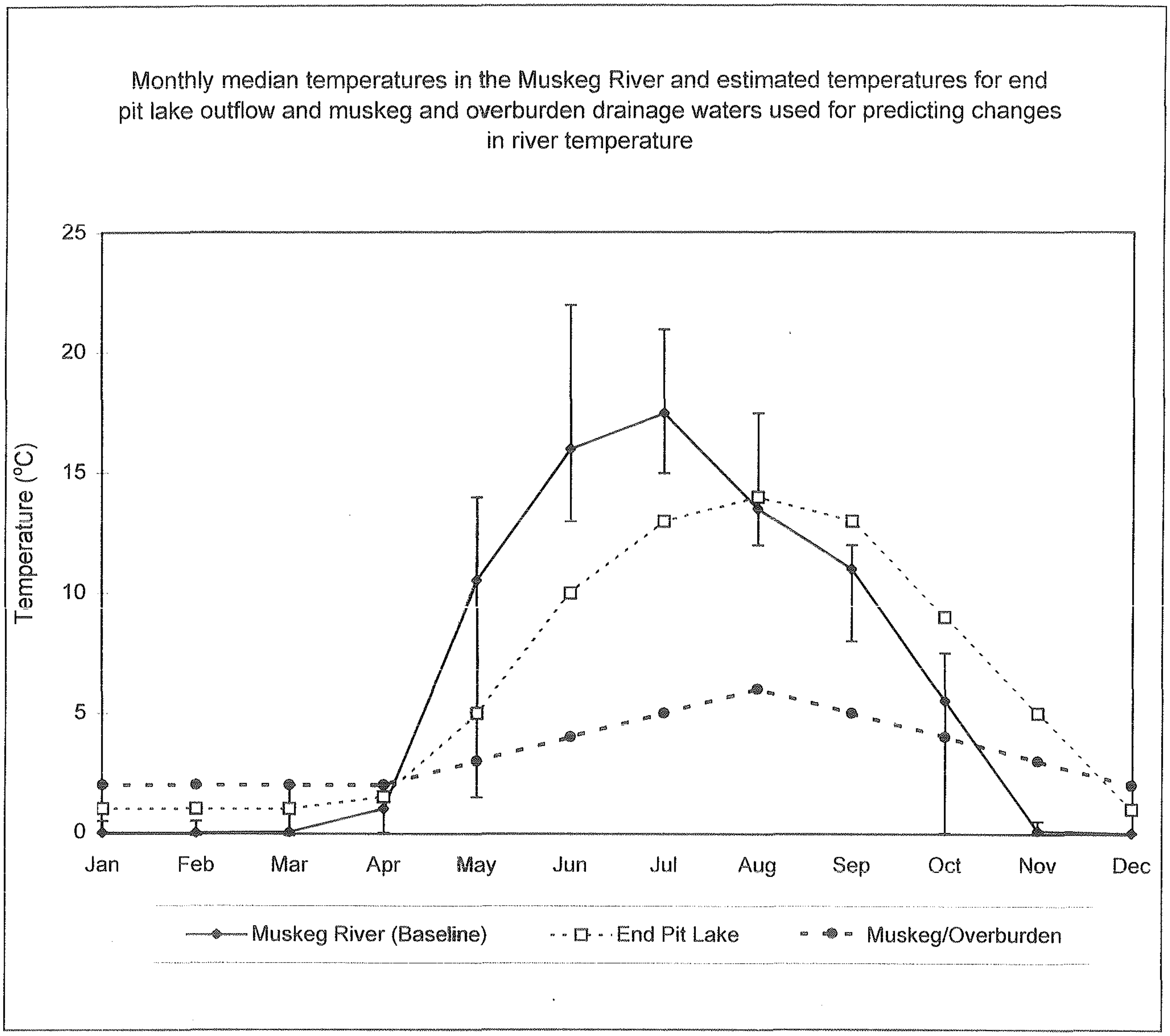


Figure 7-4: Temperature of Release Waters

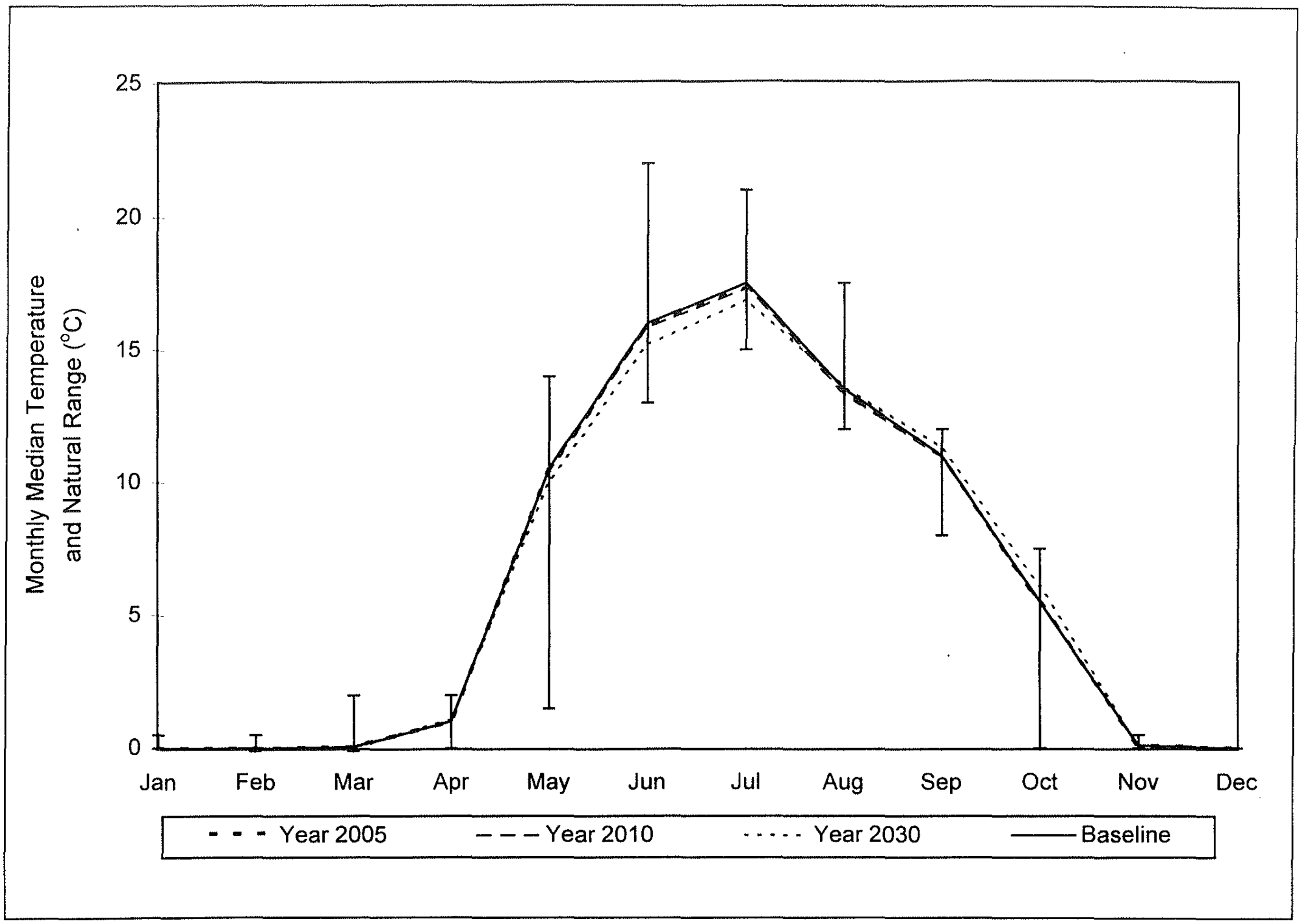
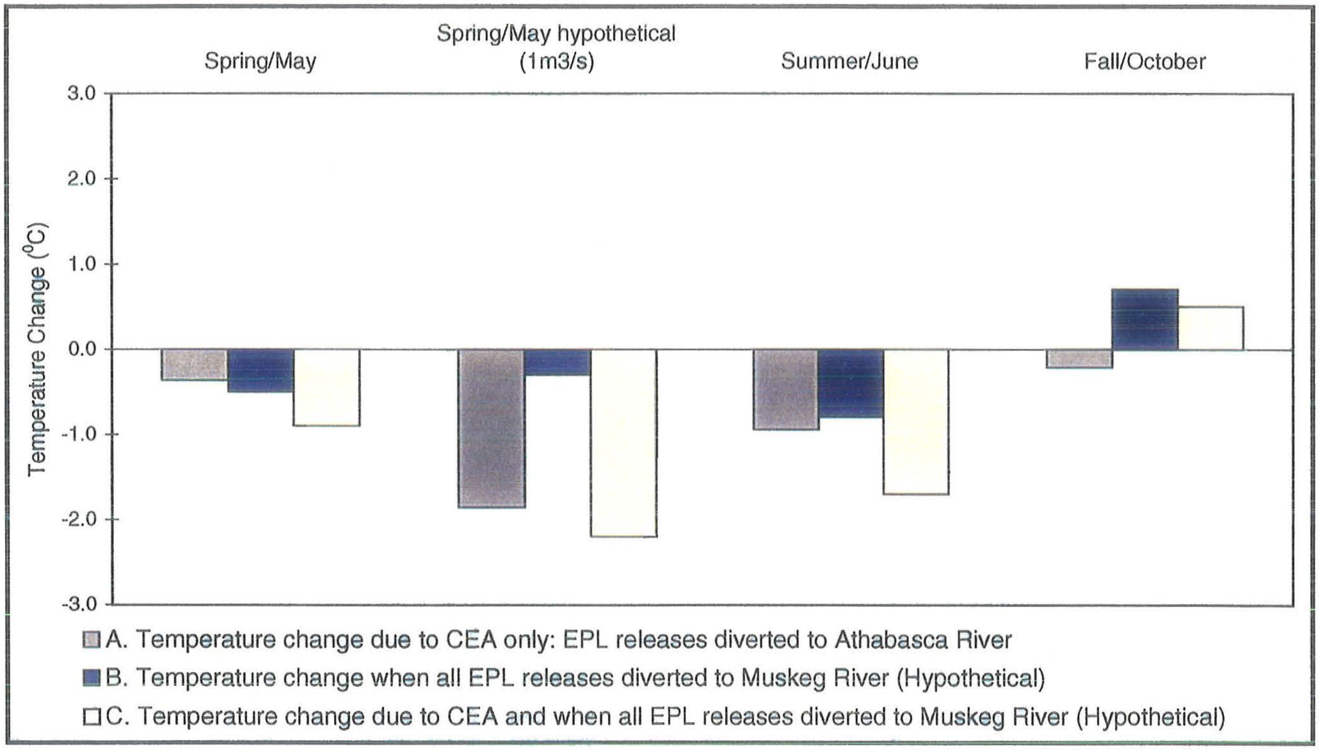


Figure 7-5: Temperature Change in Muskeg River from End-Pit Lake Alone



Season/Month	Baseline Conditions in the Muskeg River	A.	B.	C.
Spring/May	10.5 (1.5 - 14)	-0.4	-0.5	-0.9
Spring/May hypothetical (1m^3/s)	10.5 (1.5 - 14)	-1.9	-0.3	-2.2
Summer/June	16 (13 - 22)	-0.9	-0.8	-1.7
Fall/October	5.5 (0 - 7.5)	-0.2	0.7	0.5

Figure 7-6: Summary of Temperature Changes from CEA

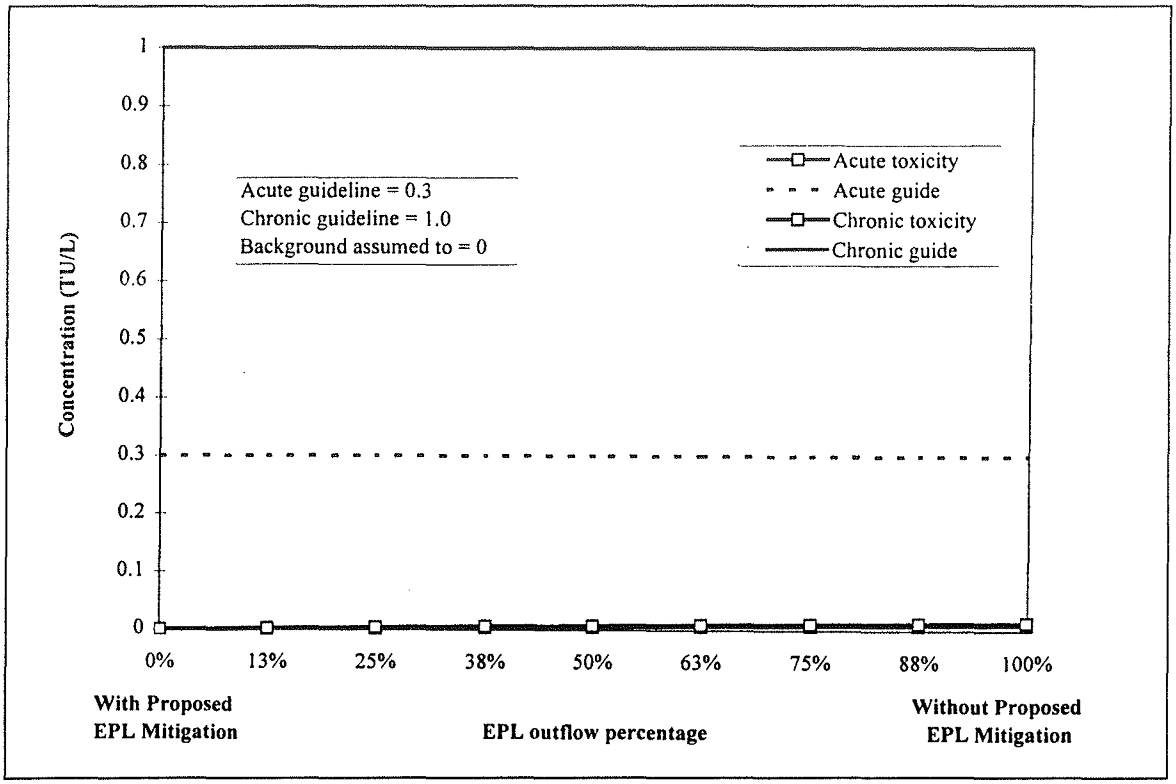


Figure 7-7: Toxicity Changes in the Muskeg River (Spring – Mean May)

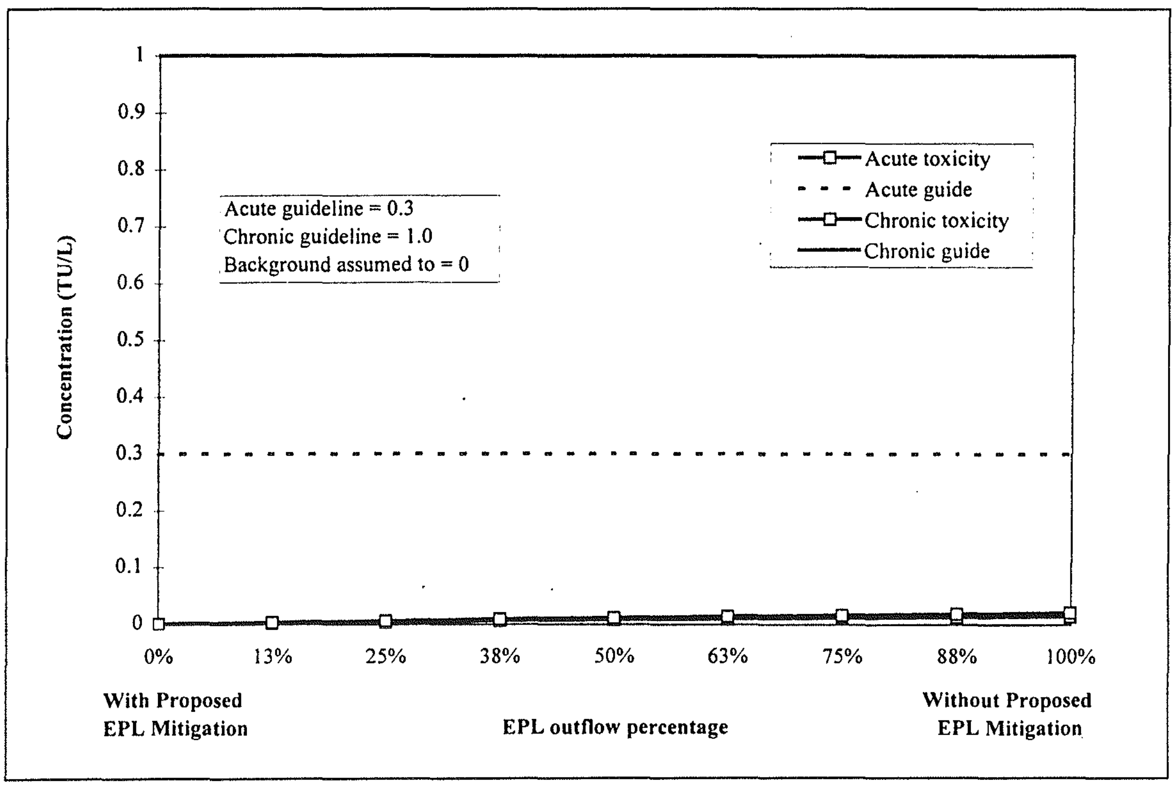


Figure 7-8: Toxicity Changes in the Muskeg River (Summer – Mean Open Water)

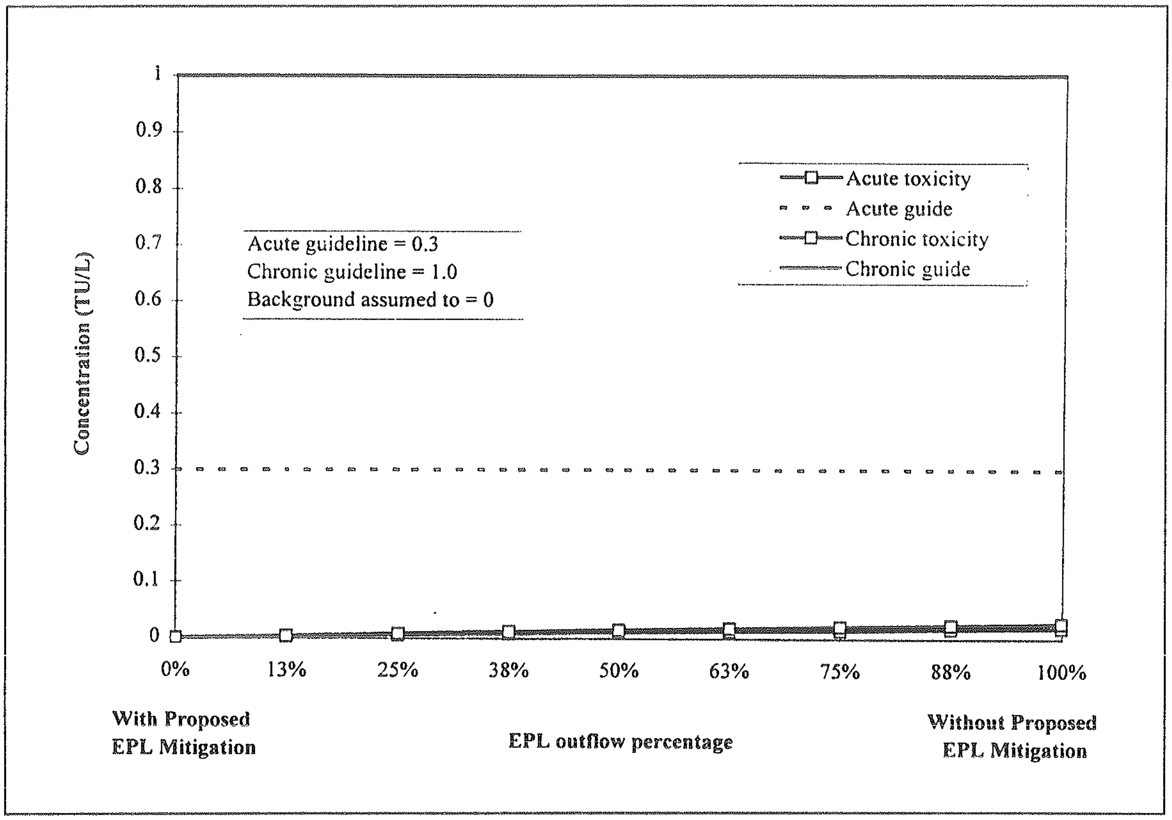


Figure 7-9: Toxicity Changes in the Muskeg River (Fall – Mean October)

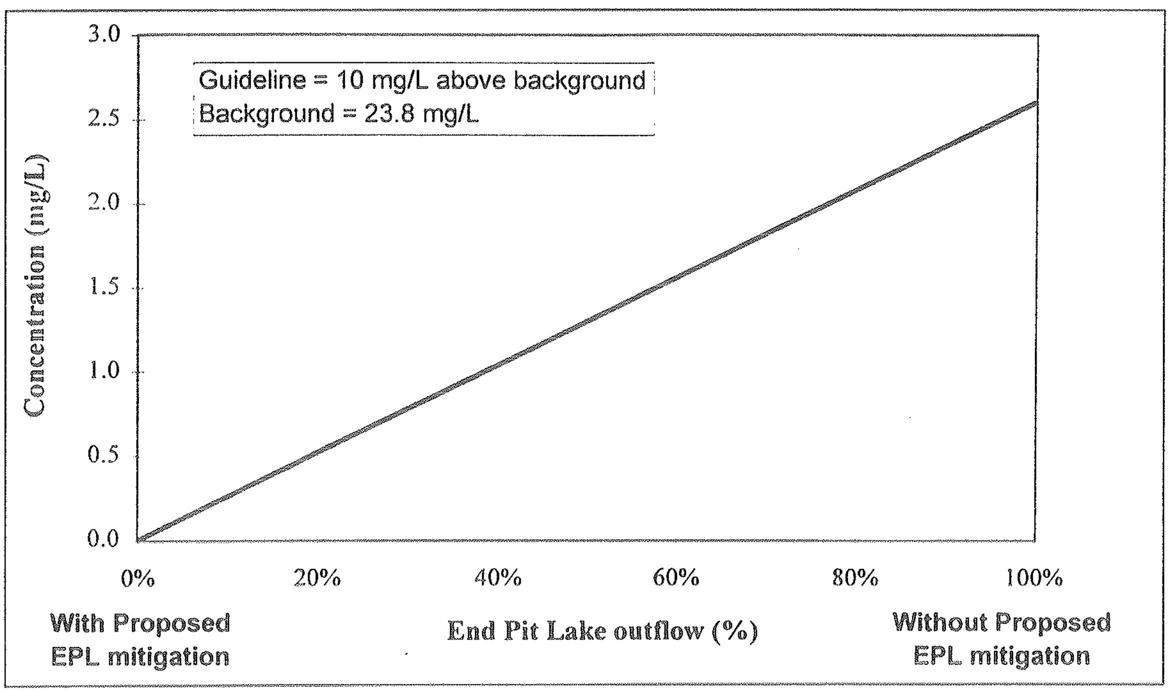


Figure 7-10: Total Suspended Solids in the Muskeg River (Spring – April to May)

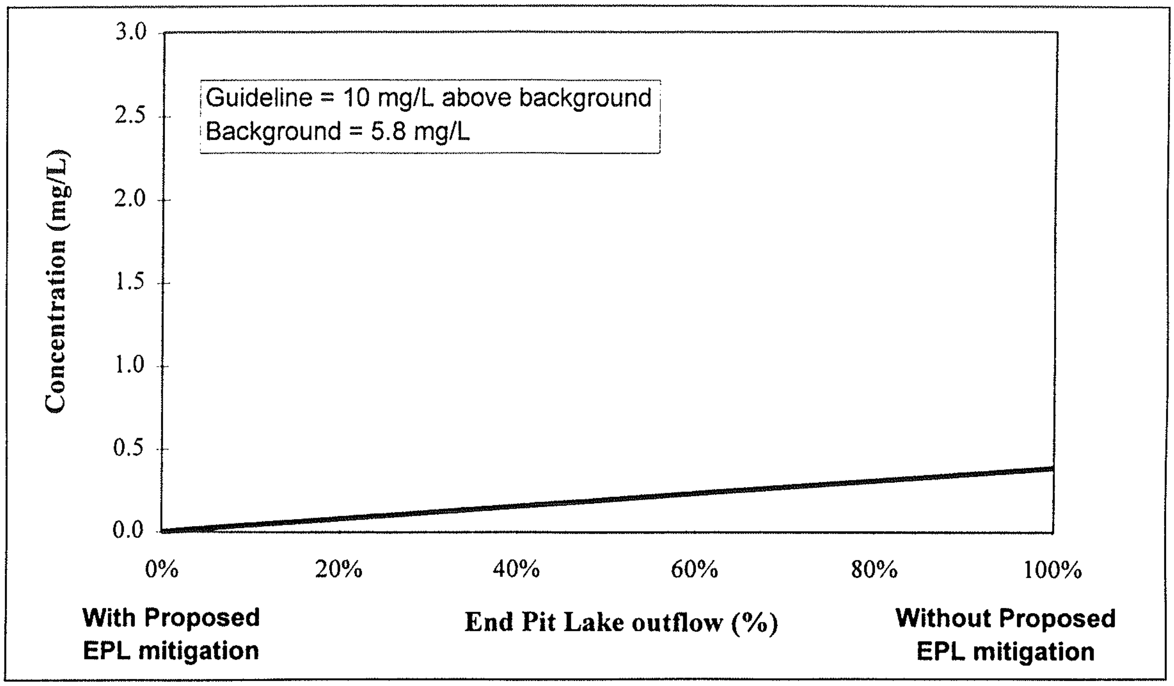


Figure 7-11: Total Suspended Solids in the Muskeg River (Summer – June to August)

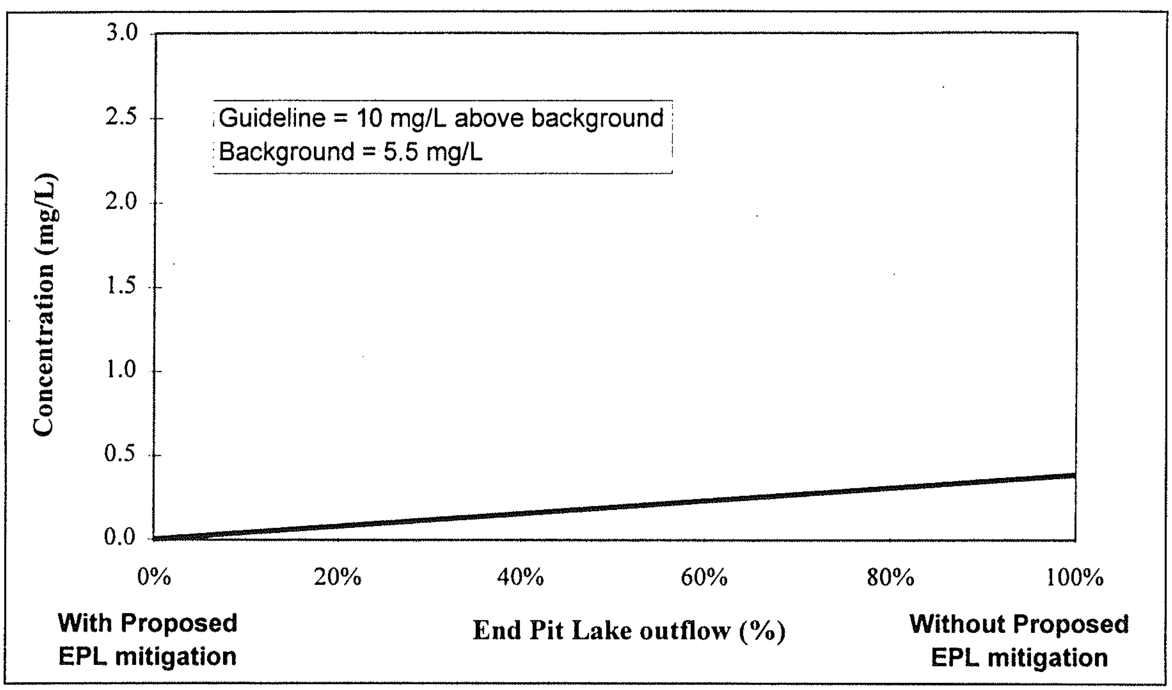


Figure 7-12: Total Suspended Solids in the Muskeg River (Fall – September to October)

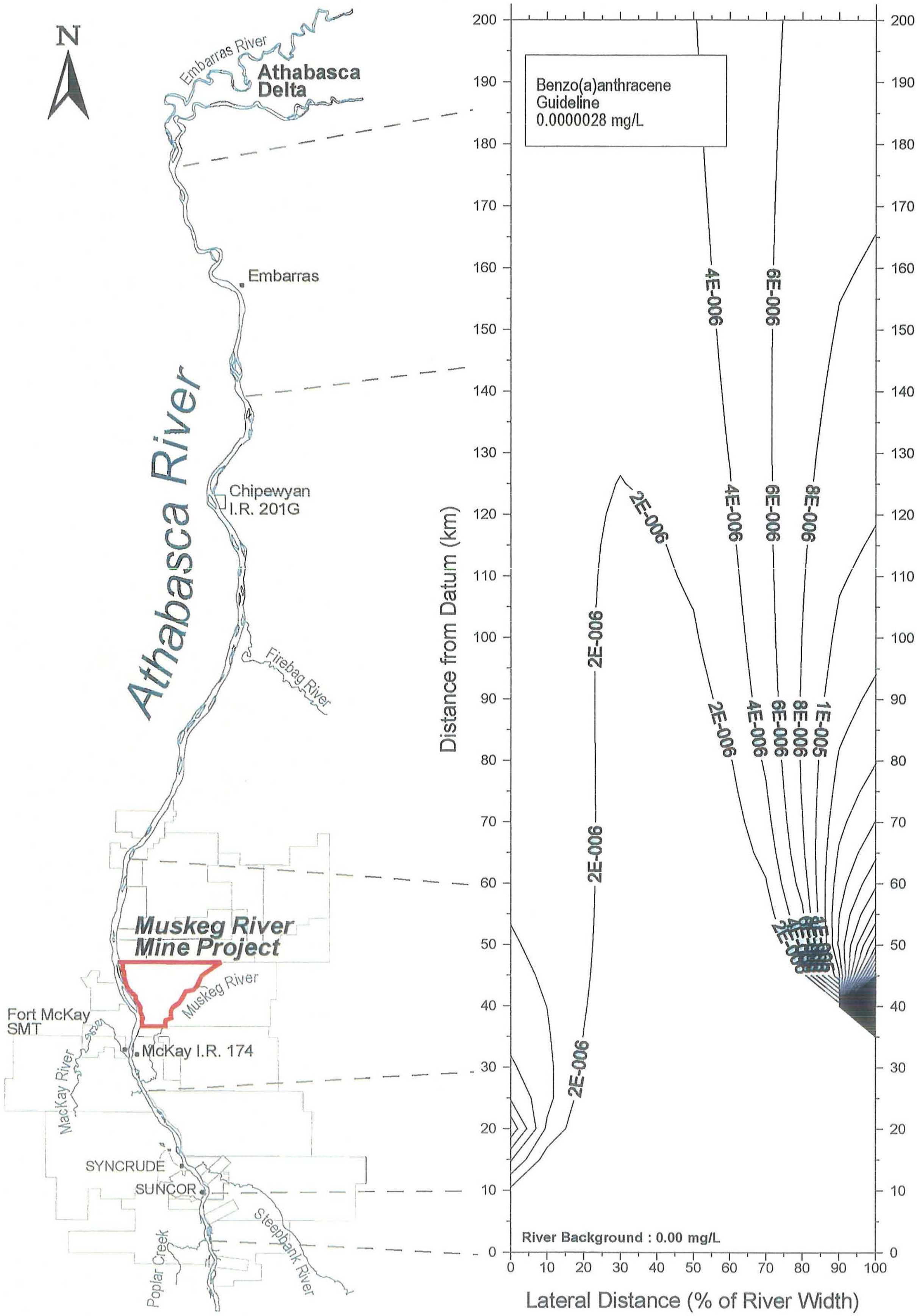


Figure 7-13: Benzo(a)anthracene Concentrations in the Athabasca River in 2030

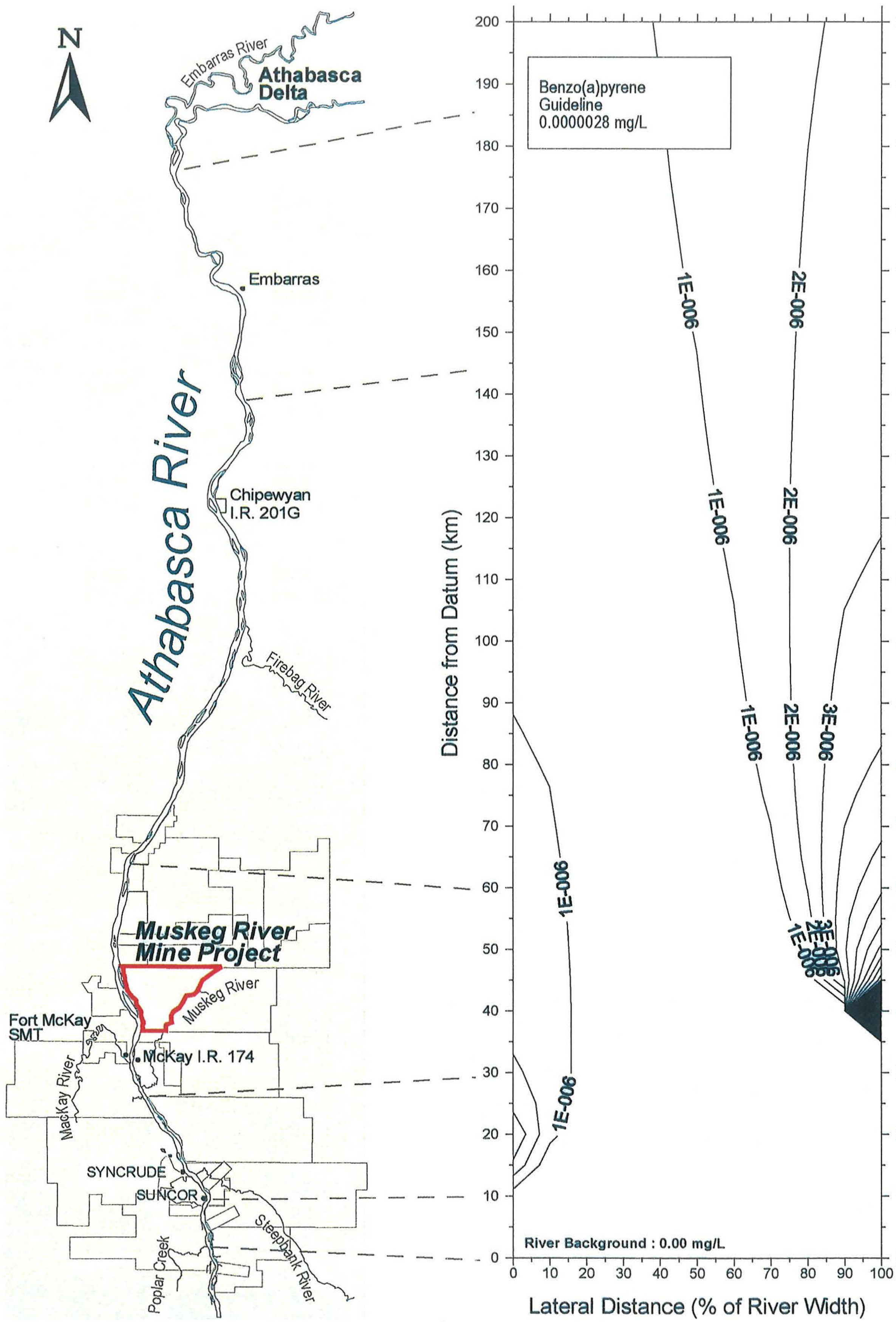


Figure 7-14: Benzo(a)pyrene Concentrations in the Athabasca River in 2030

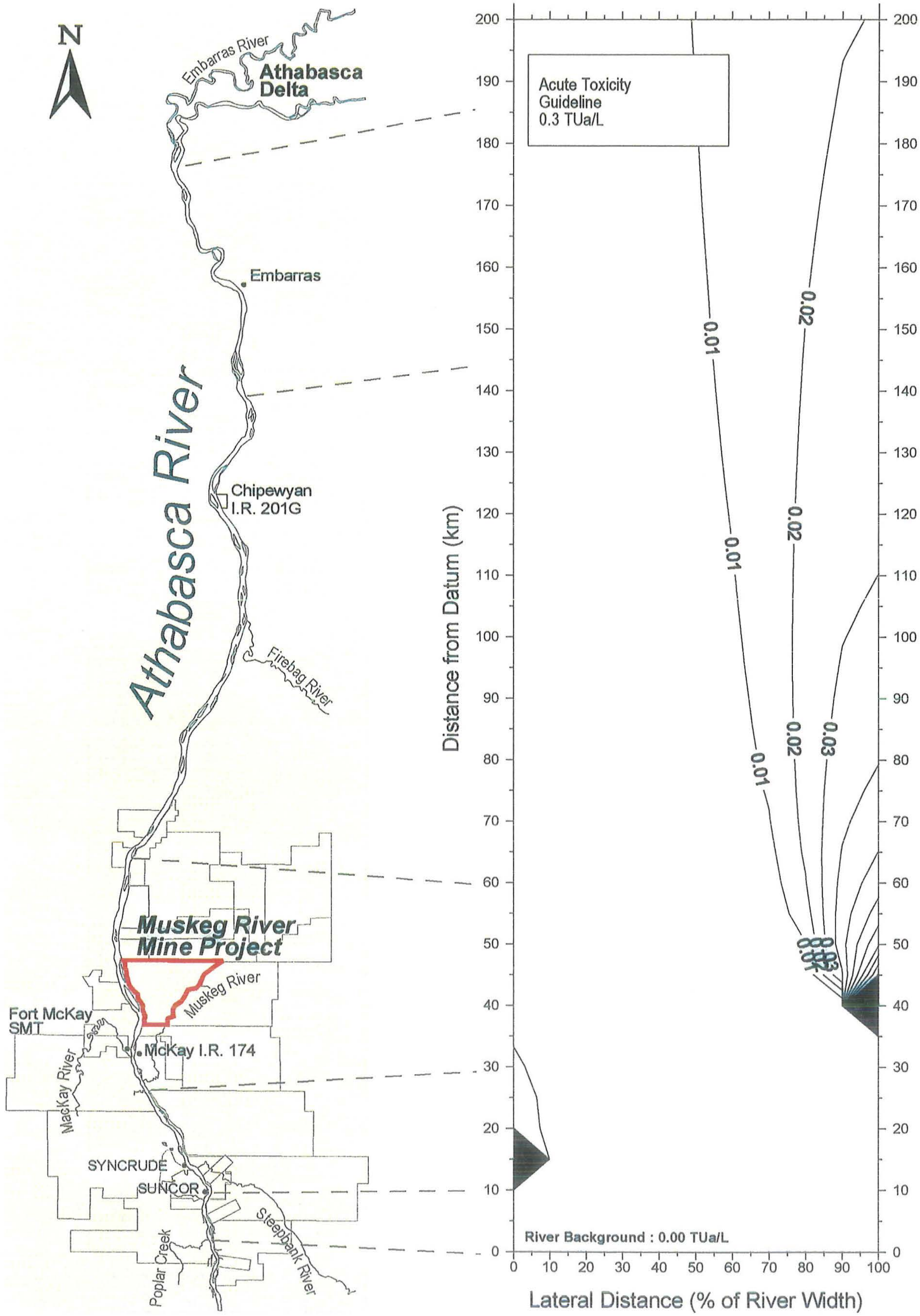


Figure 7-15: Acute Toxicity Concentrations in the Athabasca River in 2030

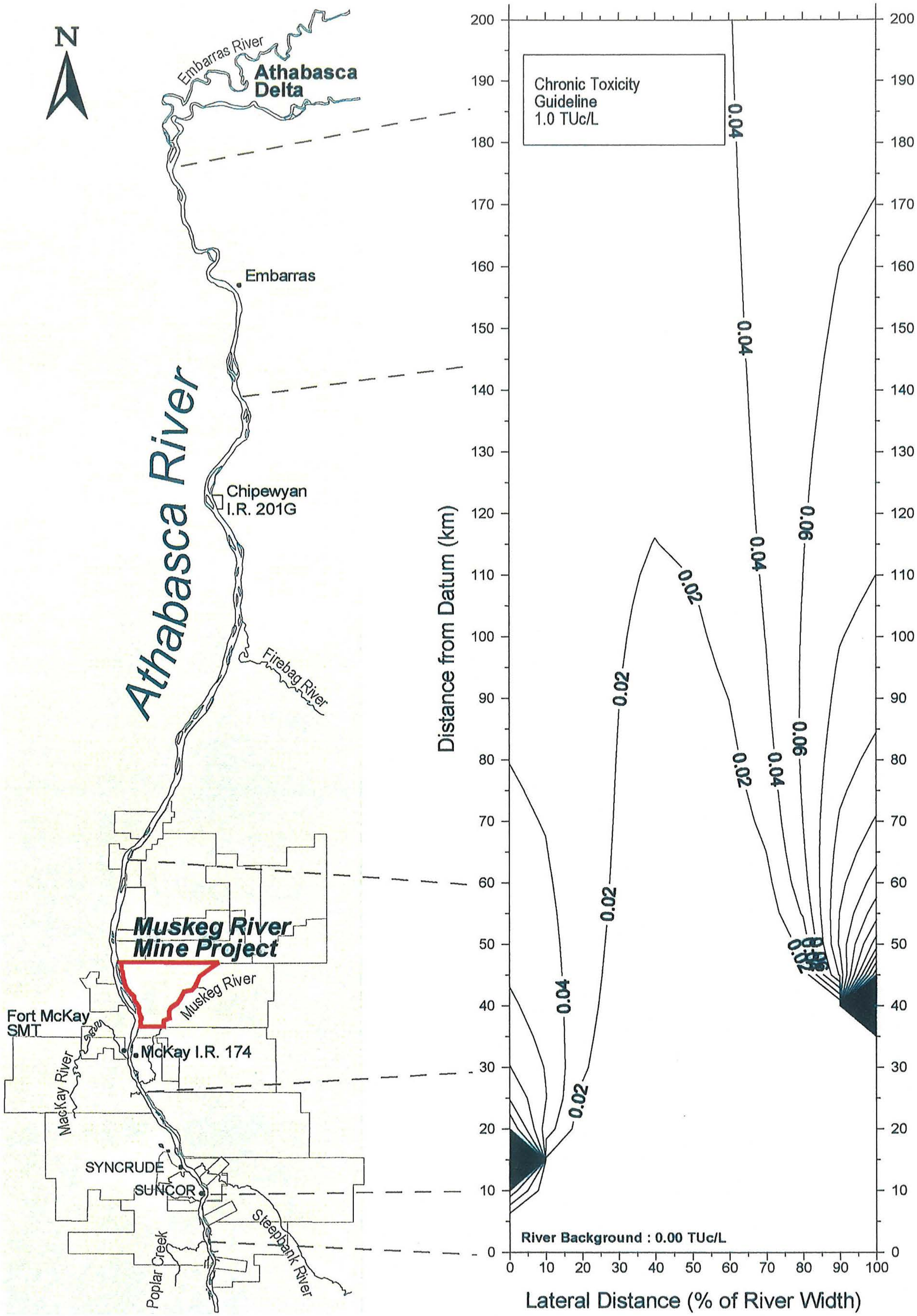


Figure 7-16: Chronic Toxicity Concentrations in the Athabasca River in 2030

Table 7-1: Effect of Varying End-Pit Lake Discharge on Muskeg River Water Quality in Spring

Parameter	Spring								
	Ratio of initial EPL outflow directed to the Muskeg River								
	0%	13%	25%	38%	50%	63%	75%	88%	100%
Aluminum - Total	0.01	0.03	0.04	0.05	0.07	0.08	0.10	0.11	0.12
Ammonia - Total	0.0002	0.002	0.004	0.006	0.008	0.01	0.01	0.01	0.01
Antimony - Total	1.1E-07	9.6E-06	1.9E-05	2.8E-05	3.7E-05	4.6E-05	5.4E-05	6.2E-05	7.0E-05
Arsenic - Total	0.0003	0.0004	0.0004	0.0005	0.0005	0.0006	0.0006	0.0007	0.0007
Barium - Total	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Benzo(a)anthracene grp	0	1.5E-06	3.0E-06	4.5E-06	5.9E-06	7.3E-06	8.7E-06	1.0E-05	1.1E-05
Benzo(a)pyrene grp	0	3.3E-07	6.5E-07	9.6E-07	1.3E-06	1.6E-06	1.8E-06	2.1E-06	2.4E-06
Beryllium-Total	2.1E-07	4.1E-05	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003
Boron - Total	0.05	0.08	0.11	0.14	0.16	0.19	0.21	0.23	0.26
Cadmium - Total	0	5.4E-05	0.0001	0.0002	0.0002	0.0003	0.0003	0.0004	0.0004
Calcium	30.2	31.0	31.8	32.6	33.4	34.1	34.9	35.6	36.3
Chloride	3.6	4.1	4.4	4.8	5.2	5.6	5.9	6.3	6.6
Chromium - Total	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003
Conductivity	209	227	244	261	277	293	309	324	339
Copper - Total	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Dissolved Organic Carbon	15.8	16.2	16.7	17.1	17.5	17.9	18.3	18.7	19.1
Iron - Total	0.56	0.58	0.60	0.62	0.63	0.65	0.67	0.68	0.70
Lead - Total	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Magnesium	8.60	8.75	8.89	9.03	9.17	9.31	9.44	9.57	9.69
Manganese - Total	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05
Mercury - Total	0	7.7E-07	1.5E-06	2.3E-06	3.0E-06	3.7E-06	4.4E-06	5.0E-06	5.7E-06
Molybdenum - Total	0.003	0.01	0.02	0.02	0.03	0.04	0.05	0.05	0.06
Naphthenic Acids	1.00	1.01	1.02	1.04	1.05	1.06	1.07	1.08	1.09
Nickel - Total	0	0.0002	0.0003	0.0005	0.0006	0.0008	0.001	0.001	0.001
Nitrate	3.4E-06	0.002	0.004	0.006	0.008	0.010	0.012	0.014	0.015
Phenolics - Total	0	0.0001	0.0002	0.0003	0.0004	0.0005	0.0005	0.0006	0.0007
Phosphorus-Total	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Selenium - Total	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Silver - Total	0	1.1E-05	2.1E-05	3.1E-05	4.1E-05	5.0E-05	6.0E-05	6.9E-05	7.8E-05
Sodium	9.0	13.0	16.9	20.7	24.4	28.0	31.5	35.0	38.4
Strontium	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.17	0.18
Sulphate	4.9	11.7	18.4	24.9	31.2	37.4	43.5	49.4	55.2
Total Dissolved Solids	143	156	168	180	192	204	215	226	237
Total PAHs	0	0.0002	0.0003	0.0005	0.0007	0.001	0.001	0.001	0.001
Toxicity - acute	0	0.001	0.002	0.004	0.005	0.006	0.007	0.008	0.009
Toxicity - chronic	0	0.002	0.004	0.005	0.007	0.009	0.010	0.012	0.013
Vanadium - Total	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.008
Zinc - Total	0.007	0.007	0.007	0.008	0.008	0.009	0.009	0.01	0.01

Table 7-2: Effect of Varying End-Pit Lake Discharge on Muskeg River Water Quality in Summer

Parameter	Summer								
	Ratio of initial EPL outflow directed to the Muskeg River								
	0%	13%	25%	38%	50%	63%	75%	88%	100%
Aluminum - Total	0.05	0.08	0.10	0.12	0.14	0.16	0.18	0.20	0.22
Ammonia - Total	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
Antimony - Total	1.7E-07	1.5E-05	3.0E-05	4.4E-05	0.0001	0.0001	0.0001	0.0001	0.0001
Arsenic - Total	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Barium - Total	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
Benzo(a)anthracene grp	0	2.5E-06	4.8E-06	7.1E-06	9.3E-06	1.1E-05	1.3E-05	1.5E-05	1.7E-05
Benzo(a)pyrene grp	0	5.2E-07	1.0E-06	1.5E-06	2.0E-06	2.4E-06	2.8E-06	3.3E-06	3.7E-06
Beryllium-Total	3.4E-07	6.5E-05	0.0001	0.0002	0.0002	0.0003	0.0004	0.0004	0.0005
Boron - Total	0.04	0.09	0.13	0.17	0.21	0.25	0.29	0.32	0.35
Cadmium - Total	0.0002	0.0003	0.0004	0.0004	0.0005	0.0006	0.0007	0.0007	0.0008
Calcium	38.4	39.6	40.7	41.8	42.8	43.8	44.8	45.7	46.7
Chloride	3.1	3.8	4.4	5.0	5.6	6.2	6.7	7.2	7.8
Chromium - Total	0.0004	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002
Conductivity	272	298	324	349	373	397	419	441	461
Copper - Total	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Dissolved Organic Carbon	22.0	22.6	23.2	23.7	24.3	24.8	25.3	25.8	26.2
Iron - Total	0.79	0.82	0.84	0.87	0.89	0.91	0.93	0.95	0.97
Lead - Total	0.0004	0.0006	0.0008	0.001	0.001	0.001	0.001	0.002	0.002
Magnesium	9.6	9.8	10.0	10.2	10.4	10.6	10.8	10.9	11.1
Manganese - Total	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.07
Mercury - Total	0.0001	9.9E-05	9.9E-05	9.8E-05	9.7E-05	9.7E-05	9.6E-05	9.6E-05	9.5E-05
Molybdenum - Total	0.0002	0.01	0.02	0.03	0.05	0.06	0.07	0.08	0.1
Naphthenic Acids	4.0	4.0	3.9	3.9	3.9	3.8	3.8	3.8	3.7
Nickel - Total	0.000	0.001	0.001	0.001	0.0013	0.0016	0.002	0.002	0.002
Nitrate	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07
Phenolics - Total	0	0.0002	0.0003	0.0004	0.0006	0.0007	0.0008	0.001	0.001
Phosphorus-Total	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Selenium - Total	4.1E-06	3.6E-05	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002
Silver - Total	0	1.7E-05	3.3E-05	4.9E-05	6.4E-05	7.8E-05	0.0001	0.0001	0.0001
Sodium	10.4	16.7	22.7	28.6	34.2	39.6	44.9	49.9	54.8
Strontium	0.06	0.08	0.10	0.12	0.13	0.15	0.17	0.18	0.20
Sulphate	4.5	15.4	25.8	35.9	45.6	55.0	64.0	72.8	81.2
Total Dissolved Solids	172	192	210	229	246	263	280	296	311
Total PAHs	0	0.0003	0.0006	0.0008	0.001	0.001	0.002	0.002	0.002
Toxicity - acute	0	0.002	0.004	0.006	0.007	0.009	0.010	0.012	0.014
Toxicity - chronic	0	0.003	0.006	0.008	0.01	0.01	0.02	0.02	0.02
Vanadium - Total	0.0004	0.002	0.003	0.005	0.006	0.007	0.01	0.01	0.01
Zinc - Total	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.01	0.02

Table 7-3: Effect of Varying End-Pit Lake Discharge on Muskeg River Water Quality in Fall

Parameter	Fall								
	Ratio of initial EPL outflow directed to the Muskeg River								
	0%	13%	25%	38%	50%	63%	75%	88%	100%
Aluminum - Total	0.06	0.09	0.12	0.15	0.18	0.21	0.23	0.26	0.28
Ammonia - Total	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07
Antimony - Total	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Arsenic - Total	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002
Barium - Total	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05
Benzo(a)anthracene grp	0	3.4E-06	6.6E-06	9.7E-06	1.3E-05	1.5E-05	1.8E-05	2.1E-05	2.3E-05
Benzo(a)pyrene grp	0	7.2E-07	1.4E-06	2.1E-06	2.7E-06	3.3E-06	3.8E-06	4.4E-06	4.9E-06
Beryllium-Total	4.8E-07	0.0001	0.0002	0.0003	0.0003	0.0004	0.0005	0.0005	0.0006
Boron - Total	0.04	0.10	0.16	0.21	0.27	0.32	0.36	0.41	0.45
Cadmium - Total	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Calcium	41.7	43.2	44.7	46.0	47.3	48.6	49.8	50.9	52.0
Chloride	4.3	5.2	6.1	6.8	7.6	8.3	9.0	9.6	10.3
Chromium - Total	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.007	0.007
Conductivity	310	346	380	413	444	474	502	529	555
Copper - Total	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003
Dissolved Organic Carbon	24.0	24.8	25.5	26.2	26.8	27.5	28.1	28.6	29.2
Iron - Total	1.14	1.17	1.19	1.22	1.24	1.26	1.28	1.30	1.32
Lead - Total	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Magnesium	9.6	9.9	10.1	10.4	10.7	10.9	11.1	11.4	11.6
Manganese - Total	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.09
Mercury - Total	0	1.7E-06	3.3E-06	4.9E-06	6.3E-06	7.7E-06	9.0E-06	1.0E-05	1.2E-05
Molybdenum - Total	0.003	0.02	0.04	0.05	0.06	0.08	0.09	0.10	0.11
Naphthenic Acids	0	0.05	0.11	0.16	0.20	0.25	0.29	0.33	0.37
Nickel - Total	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006
Nitrate	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04
Phenolics - Total	0	0.0002	0.0004	0.001	0.001	0.001	0.001	0.001	0.001
Phosphorus-Total	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06
Selenium - Total	5.8E-06	4.9E-05	9.1E-05	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003
Silver - Total	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Sodium	13.2	22	30	38	45	52	59	66	72
Strontium	0.10	0.12	0.15	0.17	0.19	0.21	0.23	0.25	0.27
Sulphate	3.8	19	33	47	60	72	84	95	106
Total Dissolved Solids	184	211	237	261	284	306	327	347	366
Total PAHs	0	0.0004	0.0008	0.001	0.001	0.002	0.002	0.002	0.003
Toxicity - acute	0	0.003	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Toxicity - chronic	0	0.004	0.01	0.01	0.01	0.02	0.02	0.02	0.03
Vanadium - Total	0.002	0.004	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Zinc - Total	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table 7-4: Predicted Water Quality in the Athabasca River With End-Pit Lake Degradation

Substance (mg/L)	CEA						RDR					
	west*		east*				west*		east*			
			below'		above'				below'		above'	
Aluminum - Total	0.68	C	0.68	C	0.68	C	0.68	C	0.68	C	0.68	C
Ammonia - Total	0.13		0.01		0.02		0.13		0.03		0.04	
Antimony - Total	1.2E-05		2.2E-07		2.2E-05		1.2E-05		4.2E-06		2.5E-05	
Arsenic - Total	0.0012	HC	0.0012	HC	0.0016	HC	0.0012	HC	0.0012	HC	0.0016	HC
Barium - Total	0.07		0.07		0.07		0.07		0.07		0.07	
Benzo(a)anthracene grp	4.7E-06	HC	2.0E-07		3.2E-06	HC	4.7E-06	HC	3.7E-06	HC	5.6E-06	HC
Benzo(a)pyrene grp	1.6E-06		5.9E-08		6.7E-07		1.6E-06		1.1E-06		1.4E-06	
Beryllium-Total	1.0E-03		1.0E-03		1.0E-03		1.0E-03		1.0E-03		1.0E-03	
Boron - Total	0.05		0.04		0.09		0.05		0.05		0.10	
Cadmium - Total	0.001		0.001		0.001		0.001		0.001		0.001	
Calcium	31.2	n.g.	30.6	n.g.	33.6	n.g.	31.2	n.g.	30.9	n.g.	33.9	n.g.
Chloride	3.5		1.8		2.8		3.5		2.0		2.9	
Chromium - Total	0.004		0.004		0.004		0.004		0.004		0.004	
Conductivity	240	n.g.	230	n.g.	271	n.g.	240	n.g.	236	n.g.	275	n.g.
Copper - Total	0.004		0.004		0.004		0.004		0.004		0.004	
Dissolved Organic Carbon	8.7	n.g.	8.4	n.g.	11.0	n.g.	8.7	n.g.	8.6	n.g.	11.0	n.g.
Iron - Total	2.99	C HNC	2.99	C HNC	2.99	C HNC	2.99	C HNC	2.99	C HNC	2.99	C HNC
Lead - Total	1.0E-04		2.4E-06		2.8E-04		1.0E-04		4.6E-05		3.2E-04	
Magnesium	7.9	n.g.	7.7	n.g.	8.2	n.g.	7.9	n.g.	7.7	n.g.	8.3	n.g.
Manganese - Total	0.40	HNC	0.40	HNC	0.40	HNC	0.40	HNC	0.40	HNC	0.40	HNC
Mercury - Total	0.0001	C	0.0001	C	0.0001	C	0.0001	C	0.0001	C	0.0001	C
Molybdenum - Total	0.006		0.0002		0.01		0.006		0.003		0.02	
Naphthenic Acids	0.27	n.g.	0.01	n.g.	0.51	n.g.	0.27	n.g.	0.27	n.g.	0.66	n.g.
Nickel - Total	9.5E-04		3.6E-06		0.0003		9.5E-04		6.8E-05		0.0004	
Nitrate	0.007		6.1E-06		0.01		0.007		0.0003		0.009	
Phenolics - Total	0.002		0.002		0.002		0.002		0.002		0.002	
Selenium - Total	0.0002		0.0002		0.0003		0.0002		0.0002		0.0003	
Silver - Total	1.6E-05		2.4E-07		2.0E-05		1.6E-05		4.6E-06		2.3E-05	
Sodium	17.9	n.g.	6.5	n.g.	14.7	n.g.	17.9	n.g.	7.8	n.g.	15.5	n.g.
Strontium	0.22	n.g.	0.22	n.g.	0.22	n.g.	0.22	n.g.	0.22	n.g.	0.23	n.g.
Sulphate	22.8	n.g.	19.5	n.g.	30.4	n.g.	22.8	n.g.	22.2	n.g.	32.3	n.g.
Total Dissolved Solids	156	n.g.	150	n.g.	178	n.g.	156	n.g.	154	n.g.	181	n.g.
Total PAHs	8.9E-05	n.g.	3.9E-06	n.g.	3.4E-04	n.g.	8.8E-05	n.g.	7.5E-05	n.g.	3.9E-04	n.g.
Acute Toxicity (TUa)	0.008		3.3E-04		0.003		0.008		0.008		0.008	
Chronic Toxicity (TUc)	0.06		0.001		0.005		0.06		0.021		0.018	
Vanadium - Total	0.009		0.004		0.005		0.009		0.004		0.006	
Zinc - Total	0.012		0.011		0.013		0.012		0.011		0.014	

* west and east = at 10% river width on the west and east sides of the Athabasca River; 'above and below = above and below the Muskeg River
n.g. = no guideline, A = aquatic life acute, C = aquatic life chronic, HC = human heath carcinogen, HNC = human health non-carcinogen

Table 7-5: Predicted Water Quality in the Athabasca River With End-Pit Lake Degradation (New Millennium Project Configuration)

	CEA			RDR		
		east*			east*	
Substance (mg/L)	west*	below'	above'	west*	below'	above'
Aluminum - Total	0.68 C	0.68 C	0.62 C	0.68 C	0.68 C	0.63 C
Ammonia - Total	0.08	0.01	0.02	0.07	0.01	0.02
Antimony - Total	7.7E-06	3.7E-08	2.1E-05	4.9E-06	1.5E-07	2.2E-05
Arsenic - Total	0.0012 HC	0.0012 HC	0.0015 HC	0.0012 HC	0.0012 HC	0.0015 HC
Barium - Total	0.07	0.07	0.07	0.07	0.07	0.07
Benzo(a)anthracene grp	4.0E-06 HC	3.0E-07	3.3E-06 HC	1.4E-06	7.5E-07	3.6E-06 HC
Benzo(a)pyrene grp	1.3E-06	6.4E-08	6.6E-07	5.3E-07	1.6E-07	7.3E-07
Beryllium-Total	0.001	0.001	9.3E-04	0.001	0.001	9.4E-04
Boron - Total	0.05	0.05	0.10	0.04	0.05	0.10
Cadmium - Total	0.001	0.001	0.001	0.001	0.001	0.001
Calcium	31.0 n.g.	30.8 n.g.	33.2 n.g.	30.8 n.g.	30.8 n.g.	33.3 n.g.
Chloride	2.7	3.1	3.7	2.6	4.4	4.7
Chromium - Total	0.004	0.004	0.004	0.004	0.004	0.004
Conductivity	238 n.g.	235 n.g.	269 n.g.	234 n.g.	238 n.g.	272 n.g.
Copper - Total	0.004	0.004	0.003	0.004	0.004	0.003
Dissolved Organic Carbon	8.6 n.g.	9.6 n.g.	11.8 n.g.	8.5 n.g.	9.5 n.g.	11.7 n.g.
Iron - Total	2.99 C HNC	2.99 C HNC	2.77 C HNC	2.99 C HNC	2.99 C HNC	2.78 C HNC
Lead - Total	7.2E-05	2.9E-06	2.8E-04	4.0E-05	7.6E-06	2.8E-04
Magnesium	7.8 n.g.	7.8 n.g.	8.2 n.g.	7.8 n.g.	7.8 n.g.	8.2 n.g.
Manganese - Total	0.40 HNC	0.40 HNC	0.36 HNC	0.40 HNC	0.40 HNC	0.37 HNC
Mercury - Total	1.0E-04 C	1.0E-04 C	9.4E-05 C	1.0E-04 C	1.0E-04 C	9.4E-05 C
Molybdenum - Total	0.005	4.1E-04	0.014	0.003	5.3E-04	0.014
Naphthenic Acids	0.26 n.g.	0.01 n.g.	0.50 n.g.	0.10 n.g.	0.02 n.g.	0.47 n.g.
Nickel - Total	5.5E-04	1.9E-04	4.8E-04	5.0E-04	2.1E-04	5.0E-04
Nitrate	0.004	0.000	0.009	0.004	0.0004	0.009
Phenolics - Total	0.002	0.002	0.002	0.002	0.002	0.002
Selenium - Total	0.0002	0.0002	0.0003	0.0002	0.0002	0.0003
Silver - Total	1.0E-05	2.6E-06	2.1E-05	7.2E-06	4.5E-06	2.3E-05
Sodium	14.5 n.g.	10.5 n.g.	17.5 n.g.	13.8 n.g.	11.5 n.g.	18.2 n.g.
Strontium	0.22 n.g.	0.22 n.g.	0.21 n.g.	0.22 n.g.	0.22 n.g.	0.22 n.g.
Sulphate	22.4 n.g.	19.4 n.g.	28.6 n.g.	20.4 n.g.	19.6 n.g.	28.8 n.g.
Total Dissolved Solids	155 n.g.	152 n.g.	176 n.g.	152 n.g.	154 n.g.	178 n.g.
Total PAHs	7.8E-05 n.g.	6.3E-06 n.g.	3.3E-04 n.g.	2.8E-05 n.g.	1.5E-05 n.g.	3.4E-04 n.g.
Acute Toxicity (TUa)	0.008	5.6E-05	0.003	0.004	0.0001	0.003
Chronic Toxicity (TUc)	0.04	0.006	0.008	0.03	0.006	0.008
Vanadium - Total	0.007	0.004	0.005	0.006	0.004	0.005
Zinc - Total	0.011	0.012	0.014	0.011	0.012	0.014

* west and east = at 10% river width on the west and east sides of the Athabasca River; 'above and below = above and below the Muskeg River
n.g. = no guideline, A = aquatic life acute, C = aquatic life chronic, HC = human heath carcinogen, HNC = human health non-carcinogen

LONG-TERM SURFACE WATER AND AQUATIC RESOURCES MONITORING AND RESEARCH IN THE REGION

Shell has designed a long-term monitoring program and recommended two research programs for detecting and understanding the effects of the Muskeg River Mine on potential water quality and aquatic resources. The proposed monitoring program is an amalgamation of the existing regional monitoring programs, which Shell supports, and supplemental monitoring sites specifically designed to detect the effects of the Muskeg River Mine project. The program is outlined in three sections:

- monitoring for local effects in the Muskeg River basin
- monitoring for regional effects in the Athabasca River
- research

Shell will work with other industries to ensure that DFO and provincial government representatives are involved in designing the regional aquatic monitoring programs, and clear objectives and a long-term mandate are set for the programs.

Monitoring Program for the Muskeg River Basin

The monitoring program for water and sediment quality, flows and aquatic resources in the Muskeg River is illustrated in Figure 7-17. Table 7-6 provides further details. The program includes:

- several stations developed under Regional Aquatic Monitoring Program (RAMP) in 1997 and 1998:
  - three thermographs on the Muskeg River (one upstream of Lease 13, one below Alsands and one at the fish fence at the mouth of the river)
  - three water quality stations (one on the Muskeg River and one each on Kearl Lake and Isadore's Lake). Conventional parameters, metals, organics, nutrients, major ions will be measured. PAHs will be assessed at the Muskeg River station.
  - one sampling area each for sediment and benthic invertebrates on the Muskeg River
  - one station (i.e., fish fence at the mouth) for fish populations and several forage fish sampling sites on the Muskeg River. The abundance and

Monitoring Program for the Muskeg River Basin (cont'd)

demographics, use of fish habitat by different life stages, and fish health parameters will be measured, and samples of fillets will be collected for contaminant analysis

  - two aquatic vegetation sampling stations on lakes (Kearl and Isadore's)

- several watercourse flow and lake level monitoring sites developed under the Shell–Syncrude–Suncor–Mobil Hydrologic Program in 1997 and 1998:
  - four watercourse stations (two on the Muskeg River, one on the Alsands drain and one on Mills Creek)
  - two hydrometric stations on Kearl Lake
- supplemental Shell monitoring sites are proposed for Isadore's Lake and the Muskeg River, and the latter all include monitoring ultra-low PAHs in sediment and the water column:
  - one new site upstream and one new site downstream of the end-pit lake outlet channel release point to monitor flow, temperature and water quality
  - one new water quality monitoring site downstream of the Muskeg River Mine
  - one new water quality monitoring site at the northern boundary of Lease 13
  - one lake level monitor on Isadore's Lake

This comprehensive monitoring program for the Muskeg River has been designed to differentiate both the Shell alone and the CEA potential effects to water, sediment and aquatic resources in the river.

Monitoring Program for Athabasca River and Selected Waterbodies

The monitoring program for water and sediment quality, flow and aquatic resources in the Athabasca River is illustrated in Figure 7-18. Table 7-7 provides further details. The program includes:

- several water quality and aquatic resource monitoring stations on the Athabasca River developed for RAMP in 1997 and 1998:
  - eight benthic invertebrate sampling areas
  - eight sediment quality sites
  - eight water quality sites

Monitoring Program for Athabasca River and Selected Waterbodies (cont'd)

- six fish habitat mapping and inventory sites
- a radiotelemetry program to track the movement of whitefish and walleye in the spring, summer and fall

- Shell will recommend to RAMP that the following modifications be included in the RAMP program:
  - add PAH monitoring at the eight sediment sites. The analysis for PAHs should be conducted at ultra-low detection levels, and include sampling of water, sediment in the water column and bottom sediments. The program will also need to verify that the proposed sediment sampling sites are located in sediment deposition sites.
  - add a water and sediment quality station (including PAHs) above the Embarras River on the Athabasca River

In addition to this monitoring program, a laboratory-based study is being designed to assess the toxicological effects of sand seepage and consolidated tailings water on fish health and tainting. This includes:

- evaluating fish tainting potential
- assessing the effects on survival, growth and production of various trophic levels (microbes, plants, invertebrates and vertebrates)
- assessing fish health
- characterizing chemically the waste waters and tissue residue

The comprehensive monitoring program and the fish health and tainting study for the Athabasca River are being designed to detect potential cumulative effects from oil sands developments on water, sediment and aquatic resources.

Research

Based on discussions with DFO, Shell is recommending that two research programs to address aquatic resource issues be designed and implemented in the region. These programs could be implemented and funded by the oil sands industry through RAMP or the Wood Buffalo Environmental Association, and involve:

- developing a dynamic simulation model for flow, temperature and quality
- studying PAHs in the Muskeg and Athabasca rivers

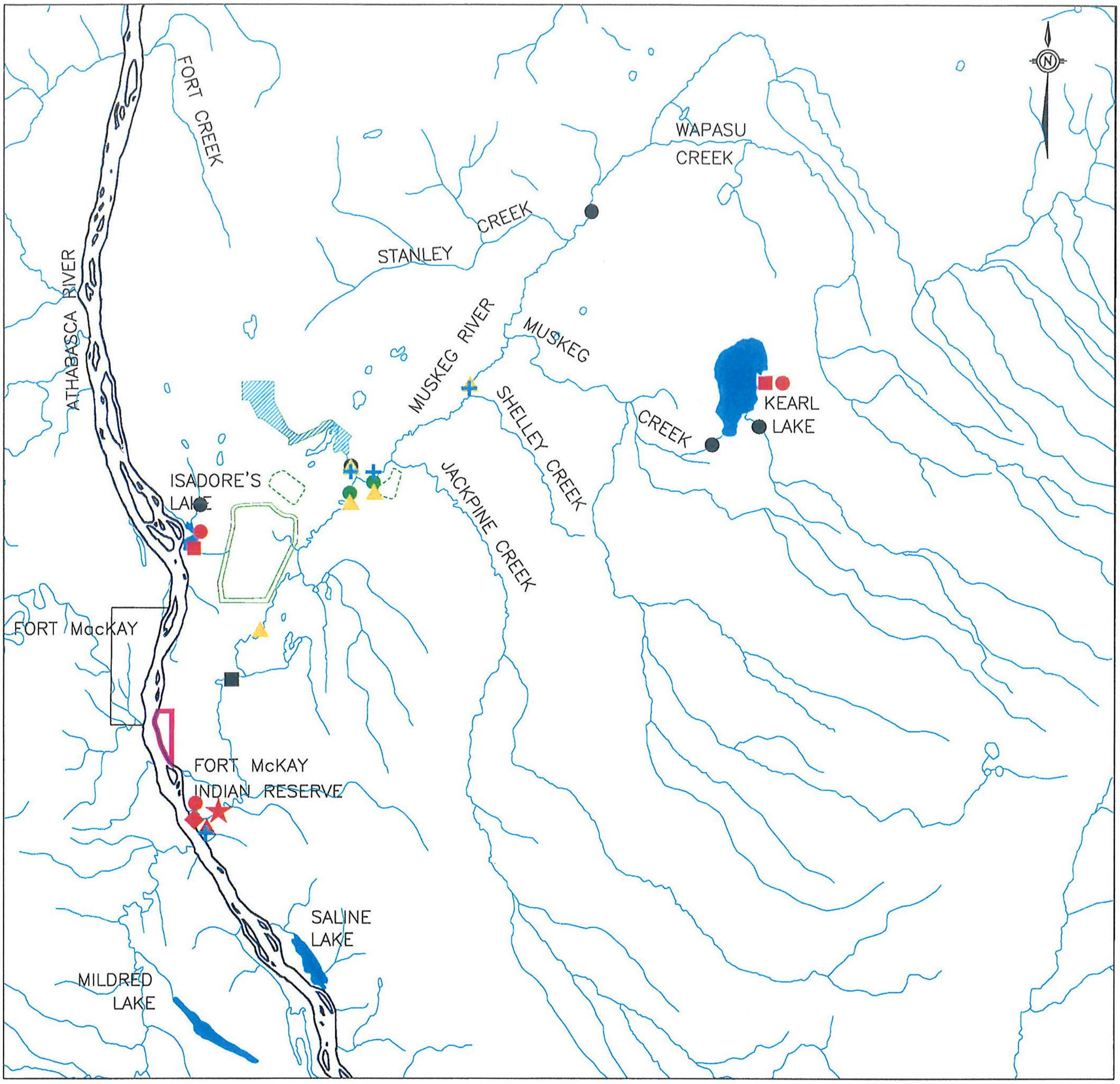
EIA model predictions, generated using conservative assumptions, indicate PAH levels from the CT release waters do not pose a risk to human health. However,

Research (cont'd)

the following information might be useful to increase Shell's understanding of the contribution of PAHs from these waters to surface waters in the oil sands area:

- ultra-low detection analyses of background PAH levels in:
  - water and sediments of natural waterbodies (see under monitoring programs for the Muskeg and Athabasca rivers)
  - reclamation waters (e.g., CT from pilot plants)
- a review of existing literature on sediment coring in the region to assess PAH levels during the pre-development oil sands period to PAH levels during the post-development period. If this review provides evidence of increased PAH levels as a result of oil sands developments, implementing further field programs in the Peace-Athabasca Delta or Lake Athabasca would be considered.

Shell recognizes that university and DFO researchers already working on PAHs could expedite such research.



LEGEND

RAMP
- WATER QUALITY SAMPLING SITES
- SEDIMENT SAMPLING SITES
- BENTHIC INVERTEBRATE SAMPLING SITES
- AQUATIC VEGETATION SAMPLING SITE
- FISH FENCE

WSC & HYDROLOGICAL SAMPLING SITES
- HYDROLOGICAL SAMPLING SITES
- WSC

SHELL
- WATER QUALITY SAMPLING SITES
- PAHs IN WATER AND SEDIMENT
- FLOWS

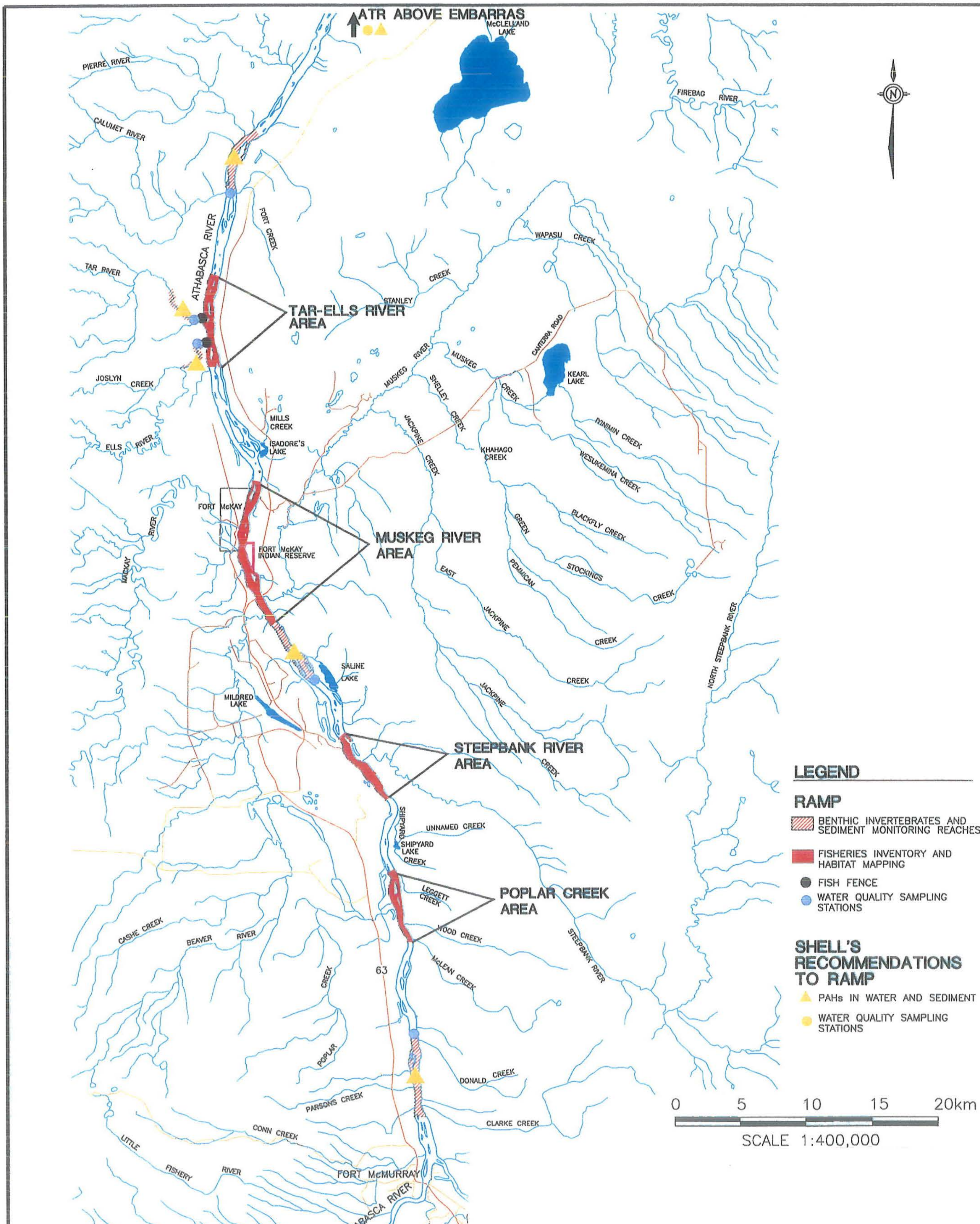
REFERENCE

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

0 5 10 15 20 25(km)

SCALE 1:50,000

Figure 7-17: Muskeg River Proposed Monitoring Locations



REFERENCE

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

Figure 7-18: Athabasca River Proposed Monitoring Locations

Table 7-6: RAMP and Shell Recommendations for the Muskeg River

	Environmental Indicators					
Monitoring Location	**Water Quality (Seasonal[1])**	**PAHs in Water Quality and Sediment (Fall)**	**Benthic Inverte-brates (Fall)**	**Aquatic Vegetation (Summer)**	**Fish (Summer and Fall[4])**	**Hydrologic Stations**
Muskeg River, near mouth	R	R, S[3]	R		R	
Muskeg River, downstream tailings settling pond	S					B (WSC)
Muskeg River, downstream Alsands Drain (end-pit lake)	S[2]					S
Muskeg River, upstream Alsands Drain (end-pit lake)	S[2]	S[3]				S
Alsands Drain (end-pit lake) outflow	S, S[2]	S[3]				B
Muskeg River, above Shelley Creek	S	S[3]				
Muskeg River, above Stanley Creek						B
Isadore's Lake or Mills Creek	R			R		B, S[5]
Kearl Lake	R			R		B

Notes:

1. Includes conventional parameters, major ions, nutrients, total and dissolved metals, organics (hydrocarbons and naphthenic acids) and temperature
2. Flow, total suspended sediments, total and dissolved metals, acute and chronic toxicity will be sampled.
3. Includes ultra-low detection for water column, sediment in water column and sediment.
4. Fish fence (location about 7 km from the mouth), sampled in spring and fall.
5. B refers to Mills Creek and S to Isadore's Lake

S = To be sampled by Shell and/or recommended to RAMP.
R = RAMP
WSC = Water Survey of Canada
B = Hydrologic Program

Table 7-7: RAMP and Shell Recommendations for the Athabasca River

	Environmental Indicators			
Monitoring Location	Water Quality (Fall[1])	PAHs and Sediment Quality (Fall)	Benthic Invertebrates (Fall)	Fish (Spring, Summer and Fall[2])
ATR at Donald Creek, east bank	R	R, S	R	
ATR at Donald Creek, west bank	R	R, S	R	
ATR below current operations, east bank	R	R, S	R	
ATR below current operations, west bank	R	R, S	R	
ATR below Fort Creek, east bank	R	R, S	R	
ATR below Fort Creek, west bank	R	R, S	R	
ATR above Embarras	S	S		
Ells River, near mouth	R	R, S	R	R(3)
Tar River, near mouth	R	R, S	R	R(3)
Steepbank River Area				R
Popular Creek Area				R
Muskeg River Area				R
Tar-Ells River Area				R

Notes:

1. Includes conventional parameters, major ions, nutrients, total and dissolved metals, organics (hydrocarbons and naphthenic acids) and temperature
2. Fisheries habitat mapping and inventory
3. Fish fence, sampled in spring and fall

ATR = Athabasca River
S = Shell's proposal to RAMP
R = RAMP

OZONE FORMATION

CONTEXT

Key Questions AQ-4, AQCEA-4 and AQRDR-4 in EIA Volume 3, Part 1, Section E6 identified the potential for the photochemical formation of ozone from project and regional study area (RSA) precursor emissions. This potential has also been identified by Syncrude and Suncor. For this reason, Shell, Syncrude and Suncor have commissioned a study to:

- identify and quantify current and future biogenic and anthropogenic precursor emissions in the RSA
- apply a refined photochemical dispersion model (i.e., CALGRID) to evaluate the potential for ozone formation during representative spring and summer conditions

The initial results of this study are presented in this section. However, a number of changes have been incorporated since the Muskeg River Mine Project EIA was submitted in December 1997. For example:

- oxides of nitrogen (NO_x) and volatile organic compound (VOC) emission estimates for the RSA have been updated based on more recent data available from Syncrude and Suncor. Where appropriate, the updated values were extrapolated to estimate future emissions. The application and extrapolation has resulted in larger VOC emissions than indicated in the EIA (see Section 7.4).
- Redefined RSA development scenarios differ from those presented in the Muskeg River Mine Project EIA. Table 7-8 compares the Muskeg River Mine Project and ozone assessment development scenarios.

Although the redefined development scenarios do not have a one-to-one correspondence with the scenarios presented in the Muskeg River Mine Project EIA, the ozone assessment scenarios provide an understanding of the ozone formation potential in the RSA and can be considered conservative (i.e., overstated) relative to the Muskeg River Mine Project EIA scenarios. Specifically, NO_x and VOC emissions associated with the Future-Year Base Case will be greater than those associated with the Muskeg River Mine Project Baseline scenario. Similarly, the NO_x and VOC emissions associated with the Regional Development Review (RDR) Case are greater than those associated with the CEA scenario.

SUMMARY AND CONCLUSIONS

Baseline Summary

Maximum hourly and daily average ozone concentrations in excess of the ambient air quality guidelines have been observed in the RSA. The maximum observed values are consistent with background observations for other rural areas in Alberta. Initial CALGRID model predictions indicate the potential to form ozone due to Existing and Future-Year Base Case precursor emissions. The model indicates that the potential for exceedances of the 160 $\mu g/m^3$ hourly guideline occurs during the summer.

Project Conclusion

The maximum one-hour average ozone values are predicted to increase by less than 1% above the Future-Year Base Case as a result of Muskeg River Mine Project precursor emissions. During the spring, when high ozone values have historically been observed, the maximum predicted hourly values are less than the 160 $\mu g/m^3$ ambient air quality guideline. During summer periods with high temperatures, the maximum predicted hourly values exceed the 160 $\mu g/m^3$ ambient air quality guideline.

RDR Conclusion

The maximum one-hour average ozone values are predicted to increase by about 9% as a result of RDR precursor emissions. Exceedances of the 160 $\mu g/m^3$ ambient air quality guideline are not predicted to occur during the spring but are predicted to occur during the summer.

BACKGROUND

Secondary formation of ozone (O_3) can result from precursor NO_x and VOC emissions. A Canadian Council of Ministers of the Environment (CCME, 1990) management plan for NO_x and VOC indicated that high ozone concentrations in Canada were most severe in:

- the Lower Fraser Valley (British Columbia)
- the Windsor – Quebec corridor (Ontario and Quebec)
- the southern Atlantic Region (New Brunswick and Nova Scotia)

Although the CCME (1990) management plan does not identify Alberta as having a potential ozone problem, this issue was identified in the Shell Muskeg River Mine EIA for the RSA.

No direct O_3 emissions are released to the atmosphere from RSA sources. Ozone occurs naturally and NO emissions reduce natural O_3 levels near emission sources. However, precursor NO_x and VOC emissions can increase O_3 levels and the region of maximum production generally occurs several tens of kilometres downwind of emission sources. The production of ozone requires sufficient NO_x and VOC emissions in conjunction with appropriate meteorological conditions

BACKGROUND (cont'd)

(i.e., high solar intensity, high ambient temperature and stagnant wind systems). The meteorological requirements for the formation of ozone might be present during the summer months in the RSA (see EIA Volume 3, Part 1, Section E2.6.1). Previous applications of the SMOG model confirmed the potential to form ozone as a result of RSA precursor emissions (see EIA Volume 3, Part 1, Section E2.6.2).

BASELINE

Baseline Observations

Ambient ozone concentrations are observed at a limited number of stations. Specifically, ozone is monitored continuously at Fort McMurray and recent short-term ozone measurements have been collected at the Syncrude North Mine and at Koch Canada's background monitoring sites. Additional historical data are also available from the AOSERP program for the period March 1977 to April 1980 when ozone was measured at Birch Mountain and Bitumount.

Table 7-9 summarizes ozone statistics for Fort McMurray based on observations from 1990 to 1997. The Alberta hourly O_3 guideline concentration of 160 $\mu g/m^3$ was last exceeded in June 1993. Since then, the maximum hourly values have typically been in the 113 to 150 $\mu g/m^3$ range. The maximum 8-hour average concentration is in the 107 to 155 $\mu g/m^3$ range. These latter maximums are less than the new U.S. EPA 8-hour standard of 157 $\mu g/m^3$. While exceedances of the hourly guidelines are relatively infrequent, exceedances of the daily guideline (50 $\mu g/m^3$) occur on average about 110 days per year. Exceedances of the daily guidelines have been observed 50 to 90% of the time in rural Alberta areas compared to 10 to 40% of the time in urban areas (Angle and Sandhu, 1989).

The following figures summarize the temporal and meteorological trends associated with ozone concentrations observed in Fort McMurray between January 1990 and August 1997:

- Figure 7-19 shows a histogram of ozone concentrations. Over the period, 12% of the observed values were in excess of 0.04 ppm (79 $\mu g/m^3$).
- Figure 7-20 shows a box plot of ambient ozone concentrations on an annual basis. The highest concentrations occurred in 1990 and 1993.
- Figure 7-21 shows a similar box plot of ambient ozone concentrations on a monthly basis. Higher ozone concentrations tend to occur from March to July.
- Figure 7-22 shows high ozone concentrations can occur any time of the day but the greatest values tend to occur between 1000 and 1900.
- Figure 7-23 shows that the greatest ozone concentrations are associated with lower wind speeds (less than 4 km/h).

Baseline Observations (cont'd)

- Figure 7-24 shows that the greatest ozone concentrations are associated with SW to W wind directions.
- Figure 7-25 shows that the greatest ozone concentrations are associated with the lowest NO_x concentrations.
- Figure 7-26 shows greater ozone concentrations are associated with warmer temperatures. Ozone values in excess of 0.04 ppm (79 $\mu g/m^3$) have been associated with temperatures in the -25 to -30 °C range.

Ambient ozone concentrations observed at the AOSERP sites (Birch Mountain and Bitumount), and the Koch background sites (see Table 7-10) can be summarized as follows:

- The AOSERP monitoring results indicate greater ozone values when compared to those observed from 1990 to 1996 at the other sites.
- The higher values occurred during periods when anthropogenic NO_x emissions were lower. These values might be attributable to higher natural background values at the higher elevation AOSERP locations.
- The Koch ozone values are consistent with those observed in Fort McMurray.

As the monitoring period at the Koch site is less than one full year, only limited statistics are presented.

For comparison, the maximum one-hour average ozone concentrations observed at two remote sites in Alberta are 238 $\mu g/m^3$ (Fortress Mountain [1985 to 1987]) and 133 $\mu g/m^3$ (Hightower Ridge [1996]). The average ozone concentrations at these two sites are 84 $\mu g/m^3$ at Fortress Mountain and 74 $\mu g/m^3$ at Hightower Ridge.

The values observed in Fort McMurray are consistent with observations from northern latitudes. For example, the observed maximum hourly average O_3 concentrations at other northern locations are as follows:

- Norway, 107 to 224 $\mu g/m^3$ (Pederson and Lefohn, 1994)
- Finland, 115 to 154 $\mu g/m^3$ (Laurila and Lattila, 1994)
- Northern U.K., 107 to 209 $\mu g/m^3$ (Bower et al., 1994)

Various reasons have been proposed for the high rural ozone values, ranging from troposphere and stratosphere interactions (Angle and Sandhu, 1986; Davies and Schepbach, 1994) to long-range transport of photochemical ozone precursors (Legge and Krupa, 1990; Pederson and Lefohn, 1994).

Baseline Predictions

Each individual hydrocarbon species has a differing capability to form photochemical ozone. Updated VOC emission estimates for the RSA based on more recent information from Syncrude and Suncor were used and grouped according to photochemical production potential. The CALGRID model was applied on an event basis to evaluate the photochemical production potential for two periods:

- A five-day period in the spring was selected when ambient ozone concentrations tend to be the greatest (May 1 to May 5, 1994). During this period, ambient O_3 concentrations exceeded 130 $\mu g/m^3$ on five of the six days; temperatures exceeded 20ºC on two of the six days; net radiation exceeded 400 W/m^2 on all six days and wind speeds were in the 1.4 to 5.5 m/s range. The highest ozone concentrations were associated with the two windiest days.

- A six-day period in the summer was selected when photochemical production is expected to be the greatest because of warm temperatures and high solar radiation (July 25 to 30, 1994). During this period, peak ambient O_3 concentrations were about 60 $\mu g/m^3$ on two of the days, about 90 $\mu g/m^3$ on three of the days and were more than 130 $\mu g/m^3$ on one day. Ambient temperatures exceeded 30ºC on one of the six days, and exceeded 25ºC on the other days. Peak net radiation values were about 500 W/m^2 on three of the days and about 350 W/m^2 on the other three days. Wind speeds were typically in the 1.4 to 2.8 m/s range.

The CALMET pre-processor model was used to produce the two and three-dimensional meteorological and geographical data required by the CALGRID model. Maximum hourly average O_3 concentrations associated with the following cases were calculated:

- Biogenic Case — All anthropogenic sources of NO_x and VOC are set to zero. The BEIS (Biogenic Emission Inventory System) model was used to estimate biogenic emissions based on the RSA vegetation type and ambient temperatures.

- Existing Case — Anthropogenic RSA sources of NO_x and VOC are based on the existing case emissions (about 1997). This case includes associated biogenic emissions.

- Future-Year Base Case — Anthropogenic RSA sources of NO_x and VOC are based on a Future-Year Base Case (about 2002). This case assumes that the approved Suncor and Syncrude plant expansions and the Syncrude Aurora

North Mine (one train) have been implemented. This case includes associated biogenic emissions.

The Existing and Future-Year Base Case fugitive VOC emissions were modified to account for varying ambient temperatures and wind speeds during the

Baseline Predictions (cont'd)

respective periods. Table 7-11 indicates the respective precursor emissions (t/d) for these cases. The following are noted with respect to the precursor NO_x and VOC emissions:

- Biogenic NO_x emissions are much smaller than the Existing and Future-Year Base Case NO_x emissions.
- During the spring period, biogenic VOC emissions are comparable to the Existing and Future-Year Base Case VOC emissions.
- During the summer period, biogenic VOC emissions are much greater than the Existing and Future-Year Base Case VOC emissions.

Predictions of maximum one-hour average ozone concentrations ($\mu g/m^3$) in the RSA are presented in Table 7-12 for each day of simulation. The results indicate the following:

- Maximum O_3 concentrations associated with the Biogenic Case are typically 122 $\mu g/m^3$ for the spring and 118 $\mu g/m^3$ for the summer periods.
- The Existing Case NO_x and VOC precursor emissions (spring) increase the maximum values to 129 $\mu g/m^3$ (an increase of 7 $\mu g/m^3$ or 6% over the Biogenic Case).
- The Existing Case NO_x and VOC precursor emissions (summer) increase the maximum values to 161 $\mu g/m^3$ (an increase of 43 $\mu g/m^3$ or 36% over the Biogenic Case).
- The Future-Year Base Case NO_x and VOC precursor emissions (spring) increase the maximum value to 130 $\mu g/m^3$. This is an increase of 1 $\mu g/m^3$ (about 1%) over the Existing Case.
- The Future-Year Base Case NO_x and VOC precursor emissions (summer) increase the maximum values to 173 $\mu g/m^3$. This is an increase of 12 $\mu g/m^3$ (about 7%) over the Existing Case.
- Hourly exceedances in the RSA are predicted to occur on three of the six summer period days for the Existing Case and on four of the six summer period days for the Future-Year Base Case. No exceedances are predicted to occur for the spring period days.

For the purposes of comparison, the SMOG model predictions (Concord Environmental, 1993) indicated a maximum O_3 concentration of 185 $\mu g/m^3$

Baseline Predictions (cont'd)

associated with an anthropogenic NO_x emission of 59 t/d. This is similar to the CALGRID predictions provided, even though the models and associated input assumptions are different.

The CALGRID predictions should be viewed as preliminary, as additional review of the biogenic VOC emission estimates, a more complete quality control and a sensitivity analysis are proposed. A complete report that summarizes the application of CALGRID to the RSA is being prepared for Shell, Syncrude, and Suncor and will be filed by Shell as part of the Muskeg River Mine Project application.

PROJECT ASSESSMENT

Key Question AQ-4 in the EIA asked: "Will Muskeg River Mine Project Precursor Emissions Result in the Formation of Ozone (O_3) that exceed the air quality guidelines?" The following looks at the contribution of the Muskeg River Mine precursor emissions (i.e., the Project Case) relative to the Future-Year Base Case.

Emissions associated with the Future-Year Base Case are greater than those associated with the Muskeg River Mine Project Baseline scenario, so the following predictions will be conservative (i.e., overstated) relative to the Muskeg River Mine Project EIA Baseline scenario.

Project Predictions

Maximum one-hour average O_3 concentrations were predicted for the same spring and summer episodes. The same modeling approach with CALGRID using project precursor VOC and NO_x emissions was adopted. The predicted maximum hourly average O_3 concentrations are presented in Table 7-13. The results indicate that:

- Minimum values are associated with the warmer summer period.
- An average incremental O_3 increase of 1 $\mu g/m^3$ is associated with the spring period.
- An average incremental O_3 increase of 2 $\mu g/m^3$ is associated with the summer period.
- The maximum values are predicted to exceed the 160 $\mu g/m^3$ hourly guideline.

These results indicate a slightly enhanced potential (1% increase for the maximum predicted O_3 concentration) to form ozone as a result of Muskeg River Mine Project precursor emissions.

Project Conclusion

The impact ratings for Question A-2 are presented in Table 7-14. The evaluation is based on comparing the predicted one-hour average ozone concentration associated with the Project Case with that associated with the Future-Year Base Case and with the air quality guideline for O_3. The increase due to Muskeg River Mine precursor emissions is about 1%.

A concern over the estimation of fugitive VOC emissions from RSA oil sands operations has been raised. However, the VOC emissions associated with biogenic sources are much larger than those associated with anthropogenic sources. Therefore, this uncertainty is not likely to have a significant effect on the CALGRID predictions. The comparison of VOC emissions emphasizes the importance of estimating representative biogenic emissions. The relationships for estimating these emissions are currently based on information from more southerly latitudes, so there might be some degree of overestimation.

REGIONAL DEVELOPMENT REVIEW ASSESSMENT

An assessment of the ozone formation in the cumulative effects assessment (CEA) case was not undertaken, but was done for the RDR case. Key Question AQRDR-4 in the EIA asked: "Will the Precursor Emissions from Combined Developments Result in the Formation of Ozone (O_3) that Exceed the Air Quality Guidelines?" The following looks at the contribution of the RDR precursor emissions relative to the Future-Year Base Case.

Emissions associated with the RDR Case are greater than those associated with the CEA scenario. Therefore, the following predictions will be conservative (i.e., overstated) relative to the CEA scenario.

Maximum Predicted Ozone Levels

Table 7-15 compares the Biogenic, Future-Year Base and RDR precursor emissions (t/d). The summer period biogenic VOC emissions are still greater than the anthropogenic values in spite of the increased VOC emissions associated with the RDR. The predicted maximum hourly average O_3 concentrations are presented in Table 7-16. The results indicate that:

- Maximum values are associated with the warmer summer period.
- Average incremental O_3 increase of 3 $\mu g/m^3$ is associated with the spring period (3% increase).
- An average incremental O_3 increase of 16 $\mu g/m^3$ is associated with the summer period (9% increase).
- The maximum values are predicted to exceed the 160 $\mu g/m^3$ guideline.

Impact Question AQRDR-4: Conclusion

The evaluation is based on comparing the predicted one-hour average ozone associated with the CEA Case and that associated with the Future-Year Base Case and with the ambient air quality guideline for O_3. The increase due to RDR emissions is about 9%. Further sensitivity studies on these results are currently being completed. Monitoring for ozone concentrations in the region is currently being conducted under WBEA.

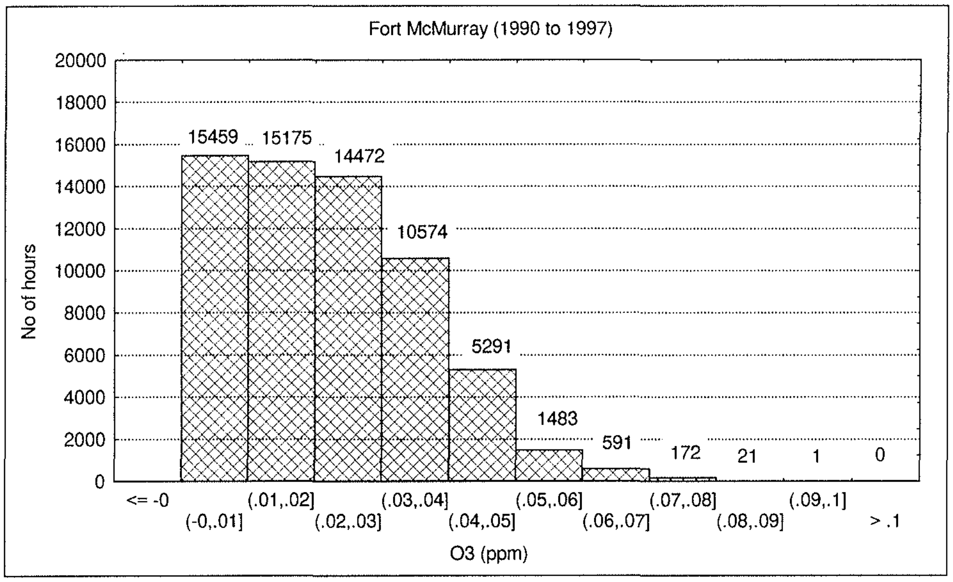


Figure 7-19: Frequency Distribution of Ambient One-Hour Ozone Concentrations

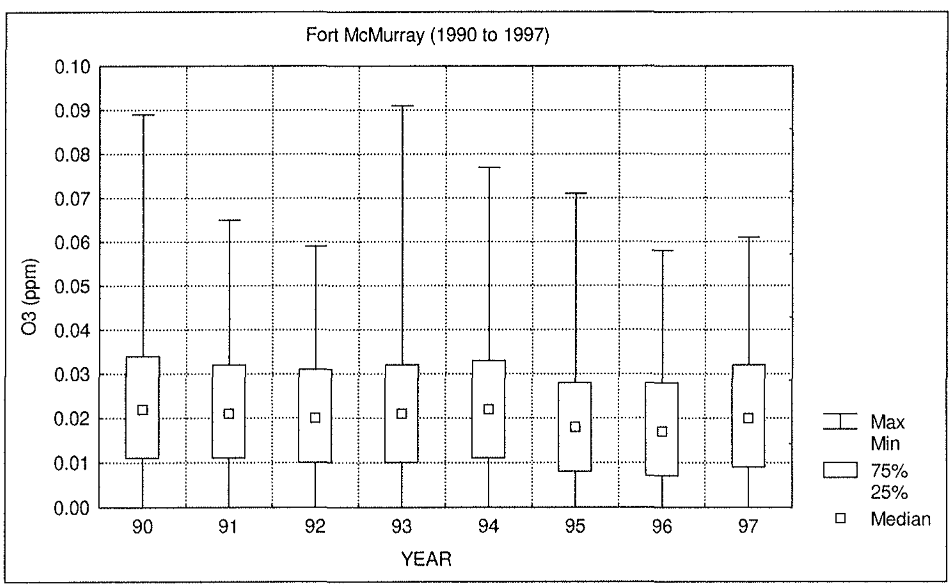


Figure 7-20: Ambient One-Hour Ozone Concentration Variation with Year

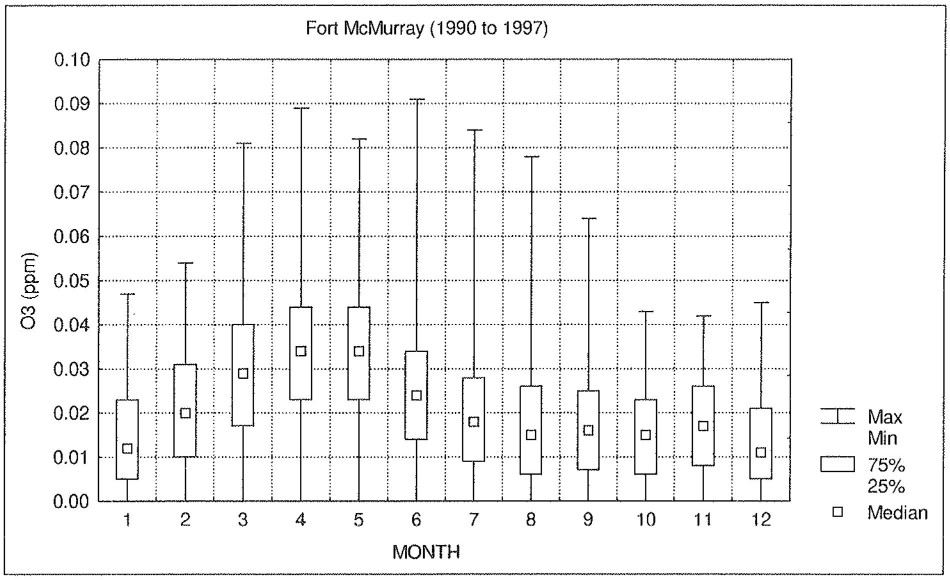


Figure 7-21: Ambient One-Hour Ozone Concentration Variation with Month

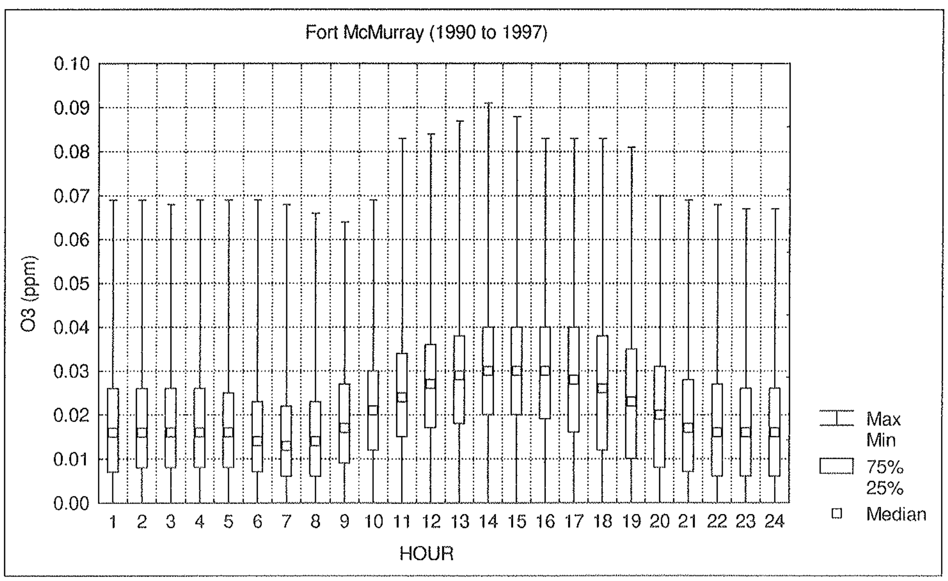


Figure 7-22: Ambient One-Hour Ozone Concentration Variation with Hour of Day

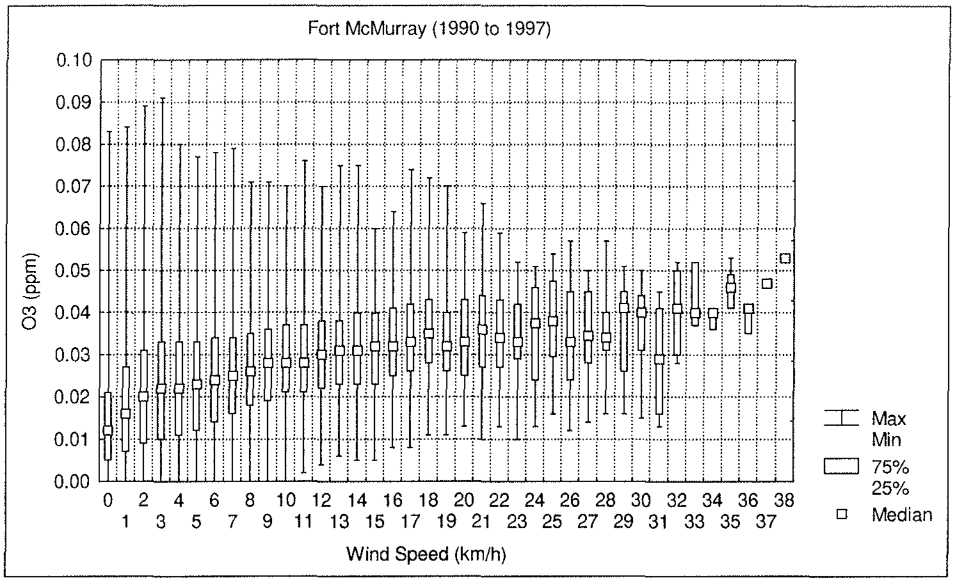


Figure 7-23: Ambient One-Hour Ozone Concentration Variation with Wind Speed

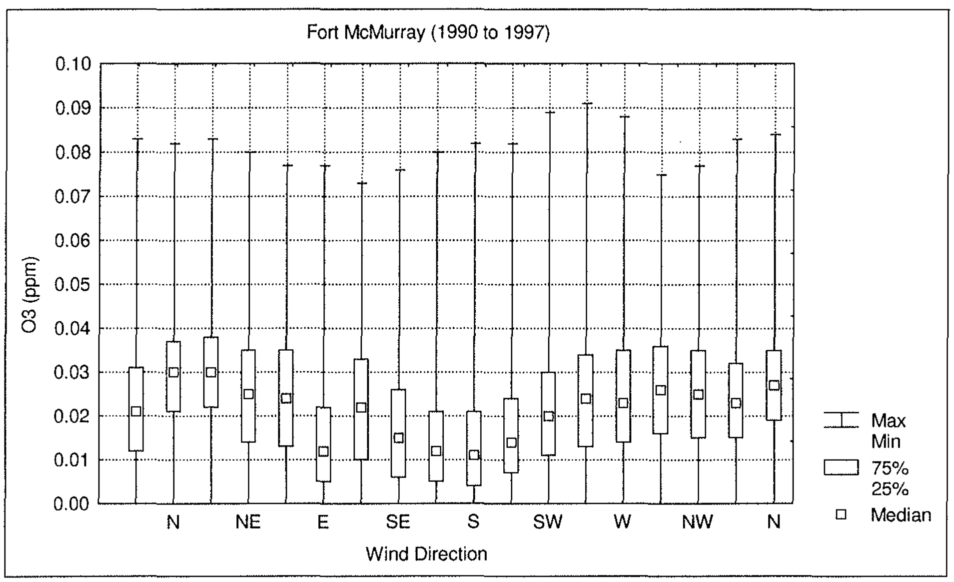


Figure 7-24: Ambient One-Hour Ozone Concentration Variation with Wind Direction

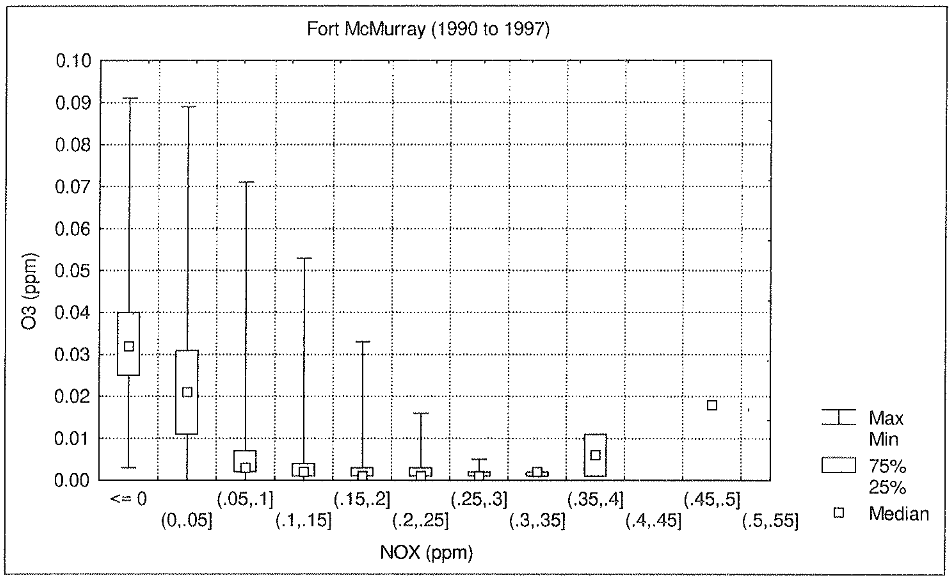


Figure 7-25: Ambient One-Hour Ozone Concentration Variation with Ambient NO_x Concentration

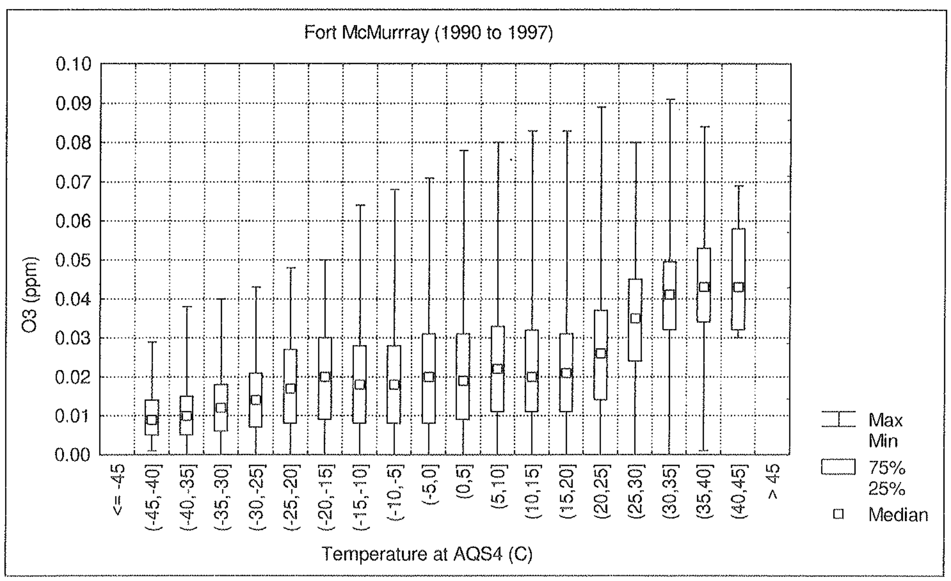


Figure 7-26: Ambient One-Hour Ozone Concentration Variation with Ambient Temperature

Table 7-8: Comparison of Muskeg River Mine Project Development and Ozone Assessment Scenarios Showing Sources with Air Emissions

Muskeg River Mine Project Impact Development Assessment Scenarios

Development	Sources
Baseline	Suncor Lease 86/17 Syncrude Mildred Lake Suncor Steepbank Gibsons Petroleum Solv-Ex
Impact Assessment	Baseline plus: Muskeg River Mine Project
Cumulative Effects Assessment (CEA)	Impact Assessment plus: Syncrude Aurora North Mine Syncrude Aurora South Mine Suncor Fixed Plant Expansion
Regional Development Review (RDR)	CEA plus: Suncor Millennium Project Shell Lease 13 East Mine Syncrude SCL 21 MLUEP Mobil Kearl Lake Mine and Upgrader Petro-Canada MacKay River JACOS Hangingstone Gulf Surmont

Ozone Assessment Scenarios

Development	Sources
Biogenic	Only biogenic NO_x and VOC sources.
Existing	Biogenic plus: Suncor Lease 86/17 Syncrude Mildred Lake Gibsons Petroleum
Future-Year Base	Existing plus: Suncor Steepbank Solv-Ex Suncor Fixed Plant Expansion Syncrude Plant Expansion Syncrude Aurora North Mine (1 train)
Muskeg River Mine Project Assessment	Future-Year Base plus: Muskeg River Mine Project
Regional Development Review (RDR)	Same as Muskeg River Mine Project RDR scenario.

Table 7-9: Ozone Concentrations Observed at Fort McMurray

	1990	1991	1992	1993	1994	1995	1996	1997
Hourly Statistics								
Mean (µg/m^3)	49	43	41	43	47	37	35	33
Median (µg/m^3)	43	41	39	41	43	35	33	31
Maximum (µg/m^3)	174	127	115	177	150	139	113	119
2nd Highest (µg/m^3)	170	125	115	172	148	133	111	119
3rd Highest (µg/m^3)	168	125	115	169	148	133	111	119
4th Highest (µg/m^3)	164	125	115	158	148	133	109	115
N ≥ 160 µg/m^3 (h/a)	18	0	0	2	0	0	0	0
8-Hour Statistics								
Mean (µg/m^3)	49	43	41	43	47	37	35	33
Maximum (µg/m^3)	155	119	111	154	142	135	107	111
2nd Highest (µg/m^3)	155	115	109	154	142	123	103	109
3rd Highest (µg/m^3)	153	115	105	150	142	123	101	107
4th Highest (µg/m^3)	152	115	103	150	142	121	101	105
N ≥ 157 µg/m^3 (h/a)	0	0	0	0	0	0	0	0
Daily Statistics								
Mean (µg/m^3)	49	43	41	43	47	37	35	33
Median (µg/m^3)	45	43	41	41	45	49	33	31
Maximum (µg/m^3)	133	84	84	105	113	98	86	86
N ≥ 50 µg/m^3 (d/a)	150	124	86	123	141	86	92	81

Note: Peak values and number of exceedances might differ from those in AEP documents as a result of differences between the AEP electronic database and the published values.

Table 7-10: Ozone Concentrations Observed at Other Locations in the RSA

	Birch Mountain (1977 to 1980)	Bitumount (1977 to 1980)	Koch (1996 to 1997)
Hourly Statistics			
Mean (µg/m^3)	72	55	-
Maximum (µg/m^3)	234	253	140
N > 160 µg/m^3 (h/a)	3	13	0
Daily Statistics			
Mean (µg/m^3)	72	55	-
Maximum (µg/m^3)	129	161	105
N > 50 µg/m^3 (d/a)	325	212	-

Table 7-11: Comparison of Biogenic, Existing and Future-Year Base Case NO_x and VOC Emissions (t/d)

Emissions	Biogenic		Existing		Future-Year Base	
(t/d)	NO_x	VOC	NO_x	VOC	NO_x	VOC
Spring						
May 1	0.5	145	51	147	108	180
May 2	0.4	111	51	162	108	201
May 3	0.5	145	51	142	108	174
May 4	0.6	173	51	149	108	184
May 5	0.8	341	51	188	108	234
Summer						
July 25	4.4	1586	51	193	108	240
July 26	3.8	1094	51	158	108	195
July 27	3.3	811	51	179	108	222
July 28	3.4	999	51	220	108	274
July 29	3.7	1108	51	140	108	172
July 30	3.5	924	51	137	108	168

Table 7-12: Predicted Maximum Hourly Average O_3 Concentrations (µg/m^3) in the RSA for the Biogenic, Existing and Future-Year Base Cases

O_3 (µg/m^3)	Biogenic	Existing	Future-Year Base
Spring			
May 1	125	127	133
May 2	125	125	125
May 3	113	123	123
May 4	125	127	127
May 5	121	142	142
Average	**122**	**129**	**130**
Summer			
July 25	127	180	195
July 26	115	148	160
July 27	115	135	139
July 28	113	176	203
July 29	117	178	178
July 30	119	150	166
Average	**118**	**161**	**173**
One-hour guideline = 160 µg/m^3			

Table 7-13: Maximum Predicted Hourly Average O_3 Concentrations ($\mu g/m^3$) in the RSA for the Biogenic, Future-Year Base and Muskeg River Mine Project Cases

O_3 ($\mu g/m^3$)	Biogenic	Future-Year Base	Muskeg River Mine Project
Spring			
May 1	125	133	137
May 2	125	125	125
May 3	113	123	125
May 4	125	127	127
May 5	121	142	142
Average	**122**	**130**	**131**
Summer			
July 25	127	195	197
July 26	115	160	160
July 27	115	139	139
July 28	113	203	205
July 29	117	178	180
July 30	119	166	170
Average	**118**	**173**	**175**
One-hour guideline = 160 $\mu g/m^3$			

Table 7-14: Classification of Air Quality Impacts Associated with Key Question AQ-4 (Ozone)

Impact Attribute	Rationale
Direction	Negative because of an increase in precursor NO_x and VOC emissions.
Magnitude	Relative to the Future-Year Base Case, the magnitude is low. The maximum one-hour ozone values are predicted to increase by less than 1% as a result of the Muskeg River Mine NO_x emissions. Relative to existing sources and natural levels, the magnitude can be defined as high, because the one-hour average ambient air quality guideline is exceeded.
Geographic Extent	Regional.
Duration	Short-term.
Reversibility	Reversible.
Frequency	Intermittent.
Season	Formation is enhanced on hot summer days when photochemical reactions are increased.

Table 7-15: Comparison of Biogenic, Future-Year Base and RDR Case NO_x and VOC Emissions (t/d) in the RSA

Emissions	Biogenic		Future-Year Base		RDR	
(t/d)	NO_x	VOC	NO_x	VOC	NO_x	VOC
Spring						
May 1	0.5	145	108	180	218	365
May 2	0.4	111	108	201	218	405
May 3	0.5	145	108	174	218	352
May 4	0.6	173	108	184	218	372
May 5	0.8	341	108	234	218	477
Summer						
July 25	4.4	1586	108	240	218	493
July 26	3.8	1094	108	195	218	400
July 27	3.3	811	108	222	218	455
July 28	3.4	999	108	274	218	562
July 29	3.7	1108	108	172	218	353
July 30	3.5	924	108	168	218	345

Table 7-16: Predicted Maximum Hourly Average O_3 Concentrations ($\mu g/m^3$) in the RSA for the Biogenic, Future-Year Base, and RDR Cases

O_3 ($\mu g/m^3$)	Biogenic	Future-Year Base	RDR
Spring			
May 1	125	133	140
May 2	125	125	125
May 3	113	123	131
May 4	125	127	129
May 5	121	142	146
Average	**122**	**130**	**134**
Summer			
July 25	127	195	207
July 26	115	160	174
July 27	115	139	154
July 28	113	203	217
July 29	117	178	193
July 30	119	166	187
Average	**118**	**173**	**189**
One-hour guideline = 160 $\mu g/m^3$			

VOLATILE ORGANIC COMPOUND EMISSIONS

CONTEXT

Key Questions AQ-2, AQCEA-2 and AQRDR-2 identified fugitive volatile organic compound (VOC) emissions from tailings settling ponds and mine surfaces as potential toxics. Key Questions AQ-4, AQCEA-4 and AQRDR-4 also identified fugitive VOC emissions as potential precursors for the formation of ozone (see Section 7.1).

The fugitive VOC emission estimates in the EIA were based on extrapolating 1987 emission factors from Syncrude's Mildred Lake Settling Basin (MLSB) to the Muskeg River Mine Project tailings settling pond. Because of its early operating history, emission factors associated with Suncor's tailings pond might not be representative of the Muskeg River Mine Project operation. The Syncrude values were selected as more representative and were used to estimate the magnitude and types of emissions that could be expected from the Muskeg River Mine Project tailings settling pond.

Since the preparation of the Muskeg River Mine Project EIA, both Suncor and Syncrude have provided updated estimates of VOC emissions from their respective ponds based on more recent studies of pond emission. This section provides updated estimates of VOC emissions from the Muskeg River Mine Project tailings settling pond based on the updated Syncrude measurements.

SUMMARY AND CONCLUSIONS

Updated emission estimates indicate that the Muskeg River Mine Project EIA VOC emissions might have been underestimated by a factor of 5. The review of ambient THC observations suggests the ambient concentrations based on the updated VOC emissions might be overestimated by a factor of 6. Therefore, the health risks undertaken in the Muskeg River Mine Project EIA might have been based on realistic concentration estimations.

The ozone assessment provided in Section 7.3 was based on the use of the updated VOC emission estimates. Because RSA summer biogenic VOC emissions are much greater than fugitive anthropogenic emissions, the predicted ozone values are not likely to be sensitive to fugitive anthropogenic VOC emission estimates.

The comparison of ambient observations with model predictions indicates uncertainty in estimating VOC emissions from the tailings settling ponds. Shell proposes to follow the resolution of emission factors associated with current operations, to obtain measurements from Muskeg River Mine pilot scale

SUMMARY AND CONCLUSIONS (cont'd)

operations and to obtain periodic measurements from the Muskeg River Mine tailings settling pond to gain a better understanding of VOC emissions. If the higher VOC emissions are indeed representative, or the VOC emissions are likely to result in a regional problem, Shell believes that mitigation measures can be applied to further reduce light hydrocarbon losses to tailings. Shell will provide any further relevant information to the EUB when it becomes available.

VOC EMISSION ESTIMATES

Updated VOC emission estimates indicate much higher VOC emissions than those provided in previous EIAs (i.e., Suncor Steepbank and Syncrude Aurora Mine). Recently released Future-Year Base Case emission estimates are provided in the Suncor Millennium EIA Technical Document (Golder and Conor Pacific 1998). Table 7-17 compares the various pond VOC estimates (t/d) as provided in various documents.

The more recent estimates reflected in the Suncor Millennium EIA Technical Document indicate a considerable increase in the VOC emissions from both ponds. The increased estimates are likely a product of changes in pond conditions (changes in diluent recovery, increased plant production and temporal changes in pond chemistry) and changes in the measurement methods applied in the different studies. If the more recent Syncrude emission factors are applied to the Muskeg River Mine tailings settling pond, the associated VOC emissions increase from the 1.5 t/d estimate given in the Muskeg River Mine Project EIA to 7.4 t/d.

Comparison with Observed Ambient Air Quality

Ambient THC and VOC concentrations in the region are the result of fugitive emissions that occur on a continuous basis from routine operations and upset events that occur intermittently. The ambient observations also depend on the meteorology at the time of the release.

Total hydrocarbons (THC) are the sum of methane (C_1 or CH_4) and non-methane hydrocarbons (NMHC or VOC). Except for special studies in which the focus of the measurements has been on VOCs, virtually all the monitoring in the study area has focused on THC as the key indicator of ambient hydrocarbon concentrations in the area.

Table 7-18 summarizes median and maximum total hydrocarbon (THC) concentrations observed as one-hour averages at selected RSA sites. Background methane values are in the range of 1.7 to 1.8 ppm or about 1.14 mg/m^3 (Khalil and Rasmussen, 1990). The measured median THC values in the study area are in the range of 0.9 to 1.4 mg/m^3, and individual values of up to 10.6 mg/m^3 have been observed. Most of the observed THC is typically methane. The extreme peaks are likely driven more by process upset events rather than by routine operations associated with poor dispersion.

Comparison with Observed Ambient Air Quality (cont'd)

As VOC emissions are not measured, attempting to extract the VOC component from the THC values becomes a challenge, because methane from local sources is one of the primary organic compounds emitted. Nevertheless, an attempt was made to derive trends in VOC concentrations with the following assumptions:

- The maximum observed values at each monitoring location were determined for each year.
- For individual years, a maximum value that is much larger than those for other years was attributed to a process upset.
- The non-extreme values were deemed to be representative of routine fugitive emissions.
- VOC values were estimated based on subtracting the background methane value.

These assumptions will result in maximum VOC estimates at the selected locations. In Fort McMurray, Fort McKay, ASQ2 and AQS4, the median THC values range from 1.1 to 1.2 mg/m^3. This compares to a global background value of 1.2 mg/m^3 for methane. This implies that 50% of the observed values were below the global background, suggesting a lack of precise control of the measurement system calibrations. Nevertheless, the difference between the THC values observed at these locations and a background value was interpreted as an indication of the ambient VOC (C_2^+). The following comments are noted:

- Fort McMurray (AEP and AQS2). The maximum ambient VOC concentrations associated with routine operations are 1.1 mg/m^3 for Fort McMurray and 1.2 mg/m^3 for AQS2. The corresponding VOC values associated with process upset maxima are 4.4 mg/m^3 for Fort McMurray and 2.8 mg/m^3 for AQS2.
- Fort McKay (AEP). The maximum routine-operation ambient VOC value is 1.2 mg/m^3 and the maximum upset VOC value is 4.3 mg/m^3.
- Fenceline (AQS4). The maximum routine-operation ambient VOC value is 2.8 mg/m^3 and the maximum upset VOC value is 9.4 mg/m^3.

Based on routine-operation fugitive emissions, the expected maximum VOC values in Fort McMurray, Fort McKay and at AQS4 are, therefore, about 1.1, 1.2 and 2.8 mg/m^3, respectively. For process upset fugitive emissions, the respective maximum VOC concentrations are 4.4, 4.3 and 9.4 µg/m^3.

Comparison with Predicted Ambient Air Quality

The maximum predicted one-hour average ambient VOC concentrations of 7.7 mg/m^3 in Fort McMurray and 6.1 mg/m^3 in Fort McKay, are based on what can be regarded as routine-operation fugitive VOC emissions (Suncor

Comparison with Predicted Ambient Air Quality (cont'd)

Millennium EIA, Table B2-25). Table 7-19 summarizes the observed and predicted VOC concentrations.

From these data, it appears that the dispersion model predictions based on the more recent studies overpredicts maximum ambient observations by a factor of about 6. A similar analysis based on recently produced RSC emissions indicates an even greater overprediction (by factors of about 6 to 12). This overprediction could result from an overestimation of emissions or the limitations with the dispersion model assumptions.

The performance of the model can be evaluated by comparing NO_x predictions with corresponding observations. NO_x emissions from mobile sources are better known than the more difficult to measure VOCs and RSCs and they also originate from surface based sources as do the VOCs and RSCs. The predicted NO_x concentrations from these sources are typically two to three times the observed values. Therefore, some of the VOC and RSC overprediction can be attributed to the model. The balance of the overprediction is likely source related, that is, the VOC (and RSC) emissions are overestimated by large margins. Hence, the more recent VOC (and RSC) emissions are likely biased and further investigation is required to determine the source of the bias.

Effects

The health risks associated with VOC emissions from the Muskeg River Mine Project were based on conservative exposure and toxicity assumptions. Although the updated emission estimates indicate that the Muskeg River Mine Project EIA VOC emissions might have been underestimated by a factor of 5, the review of ambient THC observations suggests the ambient concentrations based on the updated VOC emissions might be overestimated by a factor of 6. Therefore, the health risks undertaken in the Muskeg River Mine Project EIA might have been based on realistic concentration estimations. As a result of the conservative exposure and toxicity assumptions, even if the air quality concentrations have been underestimated, it is unlikely that human health risks have been underestimated.

The ozone assessment provided in Section 7.2 was based on the use of the updated VOC emission estimates. The results indicated that the photochemical production of ozone was controlled more by NO_x rather than VOC emissions. This is because RSA summer biogenic VOC emissions are much greater than fugitive anthropogenic emissions. Therefore, the predicted ozone values are not likely to be sensitive to fugitive anthropogenic VOC emission estimates.

Table 7-17: Estimated Tailings Pond VOC Emissions

	Syncrude MLSB	Suncor Pond 1
Shell Muskeg River EIA [1]	2.1	3.5
Aurora and Steepbank Baseline Report[2]	2.1	1.6
Suncor Steepbank EIA (for 1995)[3]	-	3.5
Suncor Millennium Technical Report[4]	14.1	83.0

Source:
1. Table D21-1 (Shell and Golder, 1997)
2. Tables A.17 and B.13 (BOVAR Environmental, 1996)
3. Table C8.0-2 (Suncor, 1996)
4. Table 3-70 (Golder and Conor Pacific, 1998)

Table 7-18: Median and Maximum THC Concentrations (mg/m^3)

		AQS2 (Fort McMurray)	AQS4 (Tailings North)	Fort McMurray (FMMU)	Fort McKay (FRMU)
Median	1990	-	1.2	1.0	1.2
	1991	1.1	1.2	1.0	1.0
	1992	1.2	2.0	1.2	1.1
	1993	1.0	1.2	1.3	1.2
	1994	0.9	1.0	1.4	1.1
	1995	1.0	1.1	1.3	1.0
	1996	1.3	1.1	1.4	1.2
	1997	-	1.2	1.4	1.1
	Median THC(1)	**1.1**	**1.2**	**1.2**	**1.1**
Maximum	1990	-	3.9	2.3	2.7
	1991	2.6	4.0	5.6 (U)	2.3
	1992	2.0	4.6	2.5	2.6
	1993	2.2	3.7	2.1	2.4
	1994	3.1	2.8	2.4	2.2
	1995	4.0 (U)(3)	9.5 (U)	2.1	5.4 (U)
	1996	2.2	10.6 (U)	2.5	2.6
	1997	-	4.9	2.1	3.1 (U)
	Normal Maximum THC(2)	**2.4**	**4.0**	**2.3**	**2.4**
	Normal Maximum VOC(4)	**1.2**	**2.8**	**1.1**	**1.2**
	Upset Maximum VOC(5)	**2.8**	**9.4**	**4.4**	**4.3**

Notes: (1) Median THC for all years.
(2) Average of maxima excluding upset values (U).
(3) Values associated with upset emissions.
(4) (Normal Maximum) – (1.2 mg/m^3 background methane).
(5) (Upset Maximum) – (1.2 mg/m^3 background methane).

Table 7-19: Observed and Predicted VOC Concentrations

	Fort McMurray (mg/m^3)	Fort McKay (mg/m^3)
Observed (O)	1.1	1.2
Predicted (P)	7.7	6.1
Ratio P/O	7.0	5.1

FORT MCKAY TRADITIONAL LAND USE REPORT

Shell contracted Fort McKay Environmental Services Ltd. to prepare a report on traditional land use by the residents of Fort McKay. The report addresses traditional land use and current resource use in the region, and traditional land use and resource use in the Muskeg River Mine local study area. The report was completed in late March 1998, and is included in Appendix A.

Shell will address issues and recommendations raised in the traditional land use report with Fort McKay during the meeting of the Industrial Relations Corporation.

PURPOSE

This section augments the socio-economic information on the outlying communities submitted as part of Shell's application for approval of the Muskeg River Mine Project.

Shell is committed to meaningful consultation with the outlying communities in order to understand their issues and concerns related to the proposed Muskeg River Mine Project. Ongoing consultation enables Shell to continue building trust and cooperative working relationships with the residents in these communities.

OUTLYING COMMUNITIES

The outlying communities in the Wood Buffalo Region are:

- Fort Chipewyan
- Fort McKay
- Anzac
- Conklin
- Janvier

FORT CHIPEWYAN

Issues

The key areas of concern for the community of Fort Chipewyan are:

- employment, training and business opportunities
- transportation to the various plants
- resources available to the school system
- shortage and adequacy of housing
- health problems that might be linked to environmental pollution
- social issues, such as:
    - family and child care
    - substance abuse
    - gaming

Issues (cont'd)

Issues directly related to the oil sands industry, and the proposed Shell development, include the availability of jobs and contracting opportunities for local residents and companies.

The issue of available and meaningful employment is linked closely to the community's concerns about human and physical resources for education. Most job opportunities are directly tied to education levels within the community.

Contracting opportunities are available to local businesses through the typical bidding process. However, the geographic distance of the community might serve as a potential barrier to these businesses.

Impacts

The total impact of direct oil sands industry employment has not been large, and future impact will depend on the types of travel arrangements that the companies will put in place. The economic activity associated with the oil sands industry has an indirect impact that is the result of community members (approximately 120 to date) leaving the community to obtain employment, mostly in Fort McMurray. Further growth may increase this migration.

The population growth in the urban service area of Fort McMurray might place stress on educational, health and other human services and might reduce access for the outlying communities within the Regional Municipality of Wood Buffalo. However, the proposed oil sands developments will increase the regional assessment base and likely increase its fiscal capacity to provide additional resources for municipal infrastructure and human service delivery in the outlying communities.

FORT MCKAY

Issues

The key areas of concern for the community of Fort McKay are:

- employment, training and business opportunities
- inadequate municipal and recreational infrastructure, especially the drinking water supply
- resources available to the school system, including transition issues associated with the necessary transfer to Fort McMurray to complete senior high school
- shortage and adequacy of housing
- health problems that might be linked to environmental pollution

Issues (cont'd)

- social issues, such as:
  - family and child care
  - substance abuse
  - gaming
- retention of traditional culture

Issues directly related to the oil sands industry, and the proposed Shell development, include the availability of jobs and contracting opportunities for local residents and companies.

The issue of available and meaningful employment is linked closely to the community's concerns regarding human and physical resources for education. Most job opportunities are directly tied to education levels within the community. Currently, only about 20% of the population 18 years or older has a Grade 12 education or higher. This makes long-term, meaningful employment a possibility for only a minority of the community.

Contracting opportunities are available to the local businesses and several significant contracts have been awarded. However, more business development resources and experience will be needed within the community if broad economic development is to occur.

Impacts

The key impact of oil sands development to the community relates to access. Road access (pre-dating the commercial oil sands industry) has positive impacts, such as better access to health, educational and other services, as well as the negative consequences of easier access to drugs, alcohol and gambling. In addition, oil sands industry activity has increased the amount of external contacts, the number of access roads, and the growth of Fort McMurray's population. These increase the pressures on the community to retain its traditional lifestyle and culture. In addition, the oil sands facilities disturb tracts of land, making them unavailable for other uses during the mining and reclamation activities.

Another key impact is on housing. There are indications that some community members who were living in Fort McMurray have returned to the community, partly to avoid increasing housing costs in the urban centre. This aggravates the existing shortage of housing within the community.

The assessment base of the RMWB will increase significantly if all announced projects proceed. This provides greater fiscal capacity for service delivery within the municipality, including Fort McKay.

ANZAC, CONKLIN AND JANVIER

Issues

The outlying communities of Anzac, Conklin and Janvier all share the same key issues:

- employment, training and business opportunities
- housing
- limited educational resources
- social issues, such as:
  - family concerns and child care
  - substance abuse

In addition, each of these communities has identified the following unique issues:

- Anzac is faced with the occasional incapacity of the community's water treatment plant to deal with industrial needs, such as water for dust control.
- Conklin faces transportation issues because of the combined condition of secondary Highway 881 and the heavy traffic.
- Janvier faces integration issues associated with Bill C-31, as members who have regained Indian status return to the community.

Impacts

Anzac's location south of much of the oil sands activity insulates it from some of the direct impacts. Anzac residents have a harder time to secure oil sands jobs and local businesses have a harder time pursuing contracting opportunities. However, recent community training initiatives have generated employment opportunities in forest fire fighting and emergency response.

Gregoire Lake is the only developed and easily accessible water-based recreation opportunity in the region and it is already heavily used by local people and by people from Fort McMurray. Increased competition for land animals and fish will likely further reduce the opportunities for traditional pursuits.

Similarly, Conklin and Janvier have been relatively unaffected by oil sands development and there have been few employment or contracting impacts to the community because of the geographic distance from most of the oil sands activity. Both communities face potential impacts from the increased population in Fort McMurray, which creates pressure on the natural resources. Hunting, fishing and camping by people outside the communities will reduce the supply of wild meat and fish available for the local residents.

POPULATION

Table 8-1 summarizes the population estimates for the outlying communities. The total population for the outlying communities is 2,655. Fort Chipewyan accounts for 40% of the population.

Table 8-1: Population

Factors	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Number of People	1060 – 1200	390	485	765	200
Groups	Mikisew Cree First Nation (64%) Athabasca Chipewyan First Nation (21%) Metis (9%) Non-aboriginal (6%)	Fort McKay First Nation (80%) Metis (15%)	Fort McMurray First Nation Metis	Metis Chipewyan Prairie First Nation	
Age Groups	over 15 years = 30% 15-19 years = 11%	over 18 years = 40%		over 25 years = 250 people	over 15 years (majority)

Note 1: Includes Anzac Hamlet and Fort McMurray First Nation Reserve.
2: Includes Janvier South Hamlet and Chipewyan Prairie First Nation Reserve.

ECONOMIC FACTORS

Table 8-2 summarizes the economic information, by community. Unemployment rates vary between 36% and 85%. All communities are faced with managing the transition from a traditional bush economy to an industrial wage-driven economy.

HUMAN SERVICES

Table 8-3 summarizes the human services available within the outlying communities. Except for Fort Chipewyan, the outlying communities rely heavily

HUMAN SERVICES (cont'd)

on Fort McMurray to provide health services, education beyond Grade 9 (with the exception of Janvier First Nation students) and most social services.

Table 8-2: Economy

Factors	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Income Sources	Hunt, fish, and trap to augment their diets Key employers are public sector organizations. About 40 businesses Seasonal employment (fishing, fire fighting)	Traditional bush Industrial wage employment	Seasonal employment (forestry, fire fighting, reforesting) Slacking Traditional bush	Social assistance Oil, gas, and forestry Traditional bush	Seasonal employment (forestry and tourism) Traditional bush
Employers		Fort McKay group of companies Few public sector jobs	First Nations administration First Nations and Metis-owned businesses	Band administration First Nation and privately owned businesses	CS Resources and PanCanadian Municipality and local businesses
Unemployment Rate	36%	36%		80 – 85%	60%
Note	1: Includes Anzac Hamlet and Fort McMurray First Nation Reserve. 2: Includes Janvier South Hamlet and Chipewyan Prairie First Nation Reserve.				

INFRASTRUCTURE

Table 8-4 summarizes infrastructures in place within the communities. Except for Fort Chipewyan, all communities have year round road access. Each community's municipal systems for central water and sewer are considered inadequate for their current populations. Housing shortages exist in each community.

Table 8-3: Human Services

Issue Area	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Education	• Head start program - (3-5 year olds). • Grades K-12. • Sahpohtawaht Training Centre offering adult education. • Keyano College satellite campus.	• Grades K-9. Students in higher grades are bussed to Fort McMurray schools. • 20% achieve Grade 12. • No post-secondary.	• Grades K-6. Students in higher grades are bussed to Fort McMurray schools.	• Grades K-9. students in higher grades are bussed to Fort McMurray schools. • First Nation students have the option to complete Grades 10-12 in the community.	• Grades K-9. students in higher grades are bussed once a week to Janvier for Career and Technology courses. • Students typically move to Fort McMurray for the higher grades. • Keyano College has a distance education site in the community.
Health Services	• Nursing station, supported by periodic visits from physicians, including a pediatrician and gynecologists. • Healing Centre focusing on public health services.	• Reliance on Fort McMurray-based health services. • Periodic community visits by home care and public health nurses.	• Reliance on Fort McMurray-based services. • Periodic visits of community health nurses. • On-reserve health service by Medical Services Branch of Health Canada include medical referrals, addiction counseling, and health awareness counseling.	• Reliance on Fort McMurray-based services. • Periodic visits of community health nurses. • On-reserve health service by Medical Services Branch of Health Canada provided by two community health representa-tives.	• Reliance on Fort McMurray-based services. • Periodic visits of community health nurses.

Table 8-3: Human Services (cont'd)

Issue Area	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Social Services	• Wide array of service providers to different groups in the community. • Family and Community Support Services focuses on seniors' programs available to all seniors. • Mikisew Community Services delivers child welfare, social assistance, and other programs to band members. • The Athabasca Chipewyan First Nation delivers social assistance and other programs to its band members. • Alberta Family and Social Services delivers programs for those persons not covered by the First Nations.	• Reliance on Fort McMurray-based social services. • Community-based child protection worker and alcohol and drug counselor. • Other social services available through Fort McMurray.	• Fort McMurray-based Family and Community Support Services program delivers homemaker services, a youth program, and a hot lunch program. These activities are supported by community-based volunteers.	• Reliance on Fort McMurray-based social services. • No Family and Community Support Services in Janvier.	• Reliance on Fort McMurray-based social services. • No Family and Community Support Services in Janvier.

Table 8-3: Human Services (cont'd)

Issue Area	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Recreation	• Kewitinok Recreation Society • Facilities – skating arena, lakefront park, three playgrounds, ball diamond, community hall. • Programs - minor hockey, minor ball, curling, weight lifting, summer fun program. • Funding – RMWB, hall rentals, and employment programs.	• Arena	• Water-based activities (Gregoire Lake) • Skating rink, ball diamonds, community hall	• Community hall, two sports fields, gymnasium, three ball diamonds, pool hall, outdoor skating rink	• Baseball diamond, playground, skating rink, 100-site campground
Emergency Services	• Volunteer fire department and ambulance service, backed up by air evacuation service to Fort McMurray and Edmonton. Air evacuation service is staffed by professional paramedics out of Fort McMurray and equipped with a plane that is stationed in Fort Chipewyan. • Five-member RCMP detachment, providing a full range of police services, including crime prevention and school liaison. • Adding tribal police officer • Provincial court sitting once a month • Justice circle	• Community-based 12 member volunteer fire department. • Community-based non-emergency ambulance service and coverage by the Fort McMurray and Syncrude-based emergency services. • Policing provided by the nine-member rural RCMP detachment, which covers the rural area of the RMWB south of Lake Athabasca.	• Volunteer fire department • Ambulance service, including air evacuation, provided by Fort McMurray Fire Department. • Policing provided by the nine-member rural RCMP detachment, which covers the rural area of the RMWB south of Lake Athabasca.	• Volunteer fire department • Ambulance service, including air evacuation, provided by Fort McMurray Fire Department. • Policing provided by the nine-member rural RCMP detachment, which covers the rural area of the RMWB south of Lake Athabasca.	• Volunteer fire department • Ambulance service, including air evacuation, provided by Fort McMurray Fire Department. • Policing provided by the nine-member rural RCMP detachment, which covers the rural area of the RMWB south of Lake Athabasca.

Notes: 1. Hamlet and Fort McMurray First Nation Reserve.
2. South Hamlet and Chipewyan Prairie First Nation Reserve.

Table 8-4: Infrastructure Summary

Issue Area	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Municipal	• Central water and sewer treatment and delivery and collections systems, although not all residences are connected. Doghead reserve is serviced by water trucks • Waste collection by the RMWB	• Central water and sewer treatment and distribution and collection pipeline systems • Solid waste disposal • Capacity of sewer system is insufficient for current flows • Connected to the power grid and serviced with natural gas • Phone service (Telus)	• Central water and sewer treatment systems, but no distribution/ collection pipeline systems • Serviced with power, natural gas and telephone • Waste transported to Fort McMurray	• Central water and sewer treatment systems, but no distribution/ collection pipeline systems • Janvier is serviced with power, natural gas and telephone There are few telephone connections in the hamlet • Waste landfill	• Central water and sewer treatment systems, but only a partial water distribution and no collection pipeline systems • Serviced with power, natural gas and telephone • Local landfill
Housing	• 292 dwellings • Seniors residence • Mikisew Cree First Nation and Athabasca Chipewyan First Nation administer housing programs • Light Island Housing Board provides rental accommod-ation	• 110 housing units • Shortage of 20 units	• 168 housing units • Seniors lodge • Plans for a 90-unit residential subdivision	• 125 housing units • Waiting list (No number)	• 57 housing units
Transport-ation	• No year-round all-weather road access • Winter road • Barge service in summer • Scheduled and chartered passenger and freight service • Airstrip and airport maintained by RMWB	• Paved year-round all-weather road access	• Paved year-round all-weather road access • Scheduled bus service	• Year-round all-weather road access; paved to Anzac and gravel between Anzac and Janvier • Twice-a-week bus service • Two airstrips	• Year-round all-weather road access; paved to Anzac, and gravel between Anzac and Conklin • Twice-a-week bus service to Fort McMurray • Two airstrips

Table 8-4: Infrastructure Summary (cont'd)

Issue Area	Fort Chipewyan	Fort McKay	Anzac[1]	Janvier[2]	Conklin
Other	• Fort Chipewyan is not connected to the power grid or natural gas distribution system. It relies on a diesel generator for power and diesel and propane for home heating • Local radio (limited) FCFN, CBC North, CFWE (Edmonton) • CBC North - only television station • No community newspaper • Nunee Health authority, Mikisew Cree First Nation distribute newsletters • Fort Smith newspaper is distributed		• Three radio stations • No cable • Power, natural gas, telephone	• No television • One radio station • Telephone, electricity and natural gas	• Newsletter • Two radio stations • Electrical, natural gas and telephone

Notes: 1. Hamlet and Fort McMurray First Nation Reserve.
2. South Hamlet and Chipewyan Prairie First Nation Reserve.

SECTION 4

Page 4-3: The Average Ore Grade column in Table 4-1 is the average feed (mining) grade. The bitumen production in column 2 is incorrectly labelled and should be "*Mm³*" not "Mbcm".

Page 4-14: The units for the strip ratio in the legend to Figure 4-3 should read "*1:1 (bcm:bcm)*".

Page 4-23: Figure 4-6, Highwall Design Detail, should show a total offset of 138 m from the Muskeg River (see the following revised version of Figure 4-6).

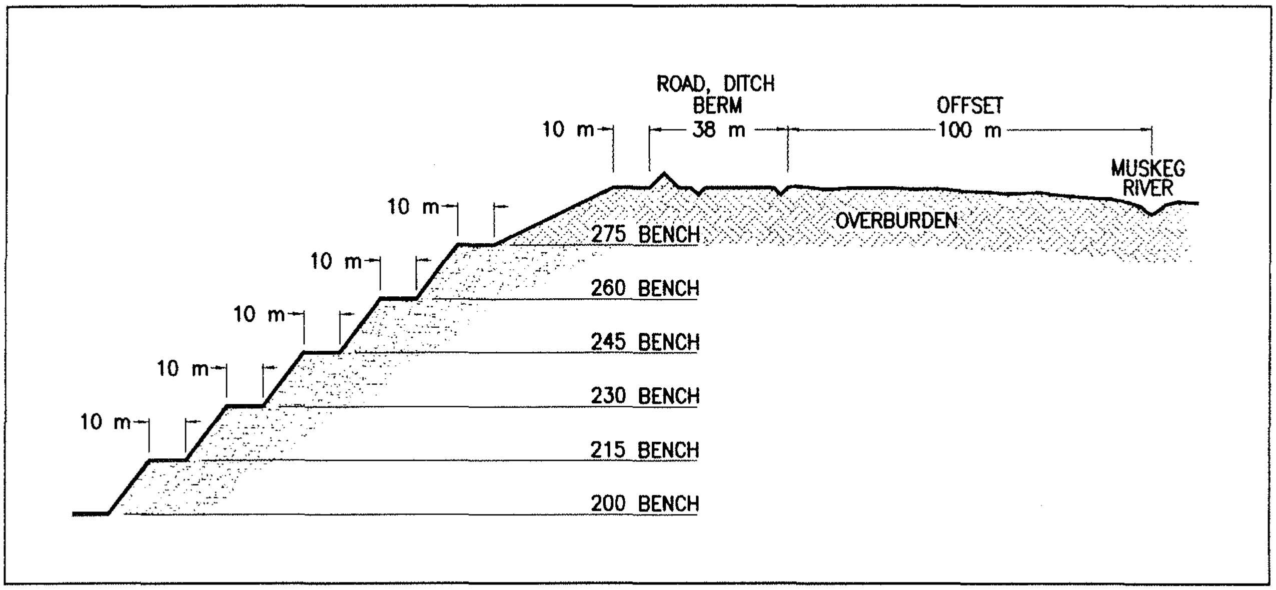


Figure 4-6 - Revised: Highwall Design Detail

Page 4-29: The text under the heading "Status at the End of 2022" incorrectly refers to Dyke 7. The reference should be to "*Cell 6*" (see Table 4-9 on p.4-36).

Page 4-31: The mining plans shown in Figures 4-9 to 4-13 do not accurately reflect the cleaning schedule outlined in Table 16-12 (p. 16-40). These plans have been revised and are shown in Section 3.6 of the Project Update.

Page 4-36: In the headings of Table 4-9, "*km3*" should read "*m³*".

SECTION 6

Page 6-28: Under the heading Design Considerations in Table 6-6, the entry for overburden starter dyke "Overburden required to a width of 2/3 of dyke height" should read "Overburden required *to a width 2/3 of four times* dyke height".

SECTION 8

Page 8-36: The heading for Total Storage in Table 8-3, should read "*Rate of Change in* Total Storage".

SECTION 16

Page 16-1: Some activities requiring AEP approval under the *Alberta Environmental Protection and Enhancement Act* and the *Water Resources Act* were inadvertently omitted. Approvals for these activities have been identified in Section 6.1, Approval Update, in the Project Update.

SECTION A

Page A-35: Under the Historical Resources Issues column, the third bullet should read "*Pre-development mitigation for significant sites* within impact zones, including the Bezya site (HhOv 730) *as required by Alberta community development*".

SECTION D2

Page D2-34: In the third paragraph, the ozone value of 0.055 should read "*55 ppb*".

Page D2-46: The reference in the first paragraph to "Appendix I2" should read: "*Appendix II*".

SECTION D4

Page D4-10: The fourth line in the first paragraph should read ". . .the 10-year wet annual precipitation is estimated to be *545 mm*, and the 10-year dry annual precipitation is 319 mm".

Page D4-13: In Table D4-5, the "*512 mm*" listed as the amount for annual areal evapotranspiration should be "*312 mm*".

Page D4-15: In Figure D4-7, the datum set at "*–20*" should be set at "*0*".

SECTION D5

Page D5-6: In Table D5-2, under the column Below Existing Oil Sands Operations, the Spring range for Cadmium should read "<2E-04 - <*0.003*".

Page D5-10: The title for Table D5-5 should read "Porewater Chemistry and Toxicity in the Athabasca, Steepbank and Muskeg Rivers and Jackpine Creek *in 1995*".

SECTION D8

In this section, all instances of the following terms should be changed:

- "glacio-fluvial" should read "*glaciofluvial*"
- "glacio-lacustrine" should read "*glaciolacustrine*"

SECTION D8 (cont'd)

Page D8-4: The heading "Glaciofluvial (GF Units)" should read "Glaciofluvial *(Fg Units)"*.

Page D8-4: The heading "Lacustrine (L Units)" should read "*Glaciolacustrine (Lg* Units)".

SECTION D10

Page D10-6: Table D10-3 should be numbered *"Table D10-1"*.

Page D10-9: Figure D10-3 should be numbered *"Figure D10-1"*.

Page D10-10: Figure D10-4 should be numbered *"Figure D10-2"*.

TERMS OF REFERENCE

Page 6: Under Surface Hydrology, the references to "Sections E4.3 and E4.9" in the last entry should read "*Sections E4.1.1* and *E4.7*".

SECTION E2

Page E2-26: In the first paragraph of Section E2.3, the reference to "Table D1-4" should be to "*Table D1-7*".

Page E2-29: In Table E2-16, the annual NO_2 guideline should be "*60 ug/m^3*" not "100" as indicated.

Page E2-46: The area numbers should be corrected as follows:

- The area where the predicted PAI exceeds 0.25 keq/ha/a increases from 1,500 to *1,800 km^2*.
- The area where the predicted PAI exceeds 0.50 keq/ha/a increases from 155 to *190 km^2*.

Page E2-54: In the last paragraph, "BOVAR 199b" should read "*BOVAR 1996b*".

SECTION E4

Page E4-45: The third paragraph, second and third sentences should be replaced with: "*There will be negligible seepage of the CT porewater to the receiving waterbodies until the CT completes its consolidation and the initial CT porewater flux has completed its movement towards the receiving waterbodies. There will be a net inflow of seepage into the CT area from the perimeter area*".

Page E4-57: The fourth paragraph, second sentence should read "...losses by up to *14 mm per year equivalent to 67,200 m^3 per year*".

SECTION E5

Page E5-1: The last sentence in the second paragraph after the bulleted list, should read "*The Cumulative Effects Assessment (CEA) in Section F5 reviews the effects of newly approved (but not yet operating) projects . . .* " The words *and planned* should be deleted.

SECTION E5 (cont'd)

Page E5-5: In Figure E5-1, the code number for the key question Will end-pit lake be toxic? should be "*WQ-6*".

Page E5-21: The fifth line in the first paragraph should read . . . "are associated with suspended particulates (*Section D5.5*)".

Page E5-41: Subsection E5.12.2, paragraph 1, line 5 should read ". . . in the province of Alberta, (*Saffran and Trew 1996.)*".

SECTION E6

Page E6-13: The first sentence in the third paragraph should refer to Section "*E4.6*". There is no Section "E4.9".

Page E6-13: The second sentence in the seventh paragraph should read "*(Key Question SW-3; Section E4.4)"*.

Page E6-13: The last sentence should refer to "*Section E4.4"*. The first sentence in the eighth paragraph should read "*(Section E4.4.2)"*.

Page E6-14: The first sentence in the second paragraph should refer to "*(Section E4.4.2)"*.

Page E6-14: The first sentence in the fourth paragraph should refer to "*(Section E4. 2)"*.

Page E6-14: The first sentence in the seventh paragraph should refer to "*(Section E4.2)*".

Page E6-15: The first sentence in the fifth paragraph should refer to "*(Section E4.2.3)"*.

Page E6-15: The fourth sentence in the fifth paragraph should refer to "*(Table E4-17)"*.

Page E6-20: The first sentence in the fourth paragraph should refer to "*Section E4.2.3"*.

Page E6-21: The first sentence in the third paragraph should refer to "*Section E4.5*".

Page E6-22: The first sentence in the fourth paragraph should refer to "*(Section E4.4.2)"*.

Page E6-22: The first sentence in the fifth paragraph should read ". . . (Key Question SW-1; *Section E4.2.3*)".

Page E6-33: The first sentence in the second paragraph should read ". . . (Key Question *SW-3; Section E4.4.2*)".

SECTION E6 (cont'd)

Page E6-35: The first sentence in the fifth paragraph should refer to "*Table E6-11*".

Page E6-41: The second sentence in the fifth paragraph should refer to "*Section E5.10*".

SECTION E7

Page E7-8: The second paragraph in subsection E7.4.2 should read "The Athabasca Upland, Susan Lake Outwash Plain, Jackpine Creek Lowland, *Jackpine Creek Upland* and Jackpine Creek Bog macroterrain units . .".

Page E7-8: Subsection E7.4.2, the last sentence in the second paragraph should read "Impacts to the Athabasca *Riparian* Terrace will be. . .".

Page E7-9: Table E7-2 contained errors. A revised version of this table follows.

Table E7-2 – Revised: Macroterrain Units Within the LSA

Macroterrain Units	LSA (ha)	Change (%)
Athabasca Upland		
Athabasca Escarpment	92	3
Athabasca Riparian Floodplain	244	3
Athabasca Riparian Terrace		
Susan Lake Outwash Plain		
Boucher Organic Plain		
Creeburn Organic Plain		
Jackpine Creek (Organic) Plain	623	
Jackpine Creek Bog		
Jackpine Creek Lowland		
Jackpine Creek Upland		
MacKay Upland		
Muskeg River/Jackpine Creek Riparian	485	1
Muskeg River Lacustrine Plain	197	7
Muskeg River Midland	1,475	42
Muskeg River Organic Lowland	358	
Reclaimed Landscapes	4,343	40
TOTAL		

Page E7-10: In Subsection E7.5.3, the second line of the second paragraph should read "The Athabasca River Valley (*escarpment and floodplain*).". ('Riparian Terrace' should not be included.)

SECTION E7 (cont'd)

Page E7-10: In Subsection E7.5.3, the sixth line of the second paragraph should read "The areas disturbed include Creeburn Organic Plain, Boucher, Organic Plain, *Athabasca Riparian Terrace* and units. . .".

Page E7-11: The fifth line of the last paragraph should read ". . . McKay Upland (28-17; 0.98-0.85) and *Muskeg River Midland* (60-58; 1.13-1.18). . .".

Page E7-13: In Table E7-6, there should not be a total listed under the Percent of Total Units Lost. This last cell should be blank.

Page E7-13: The second line of the first paragraph should read ". . . are in the Boucher Organic Plain (*66.6%*). . .".

Page E7-13: The fifth line of the first paragraph should read ". . . and *Athabasca* Riparian Terrace (30.2%)".

Page E7-15: In Table E7-8, under the column for Reversibility, sixth row, the text for the Boucher Organic Plain should read "*irreversible*".

SECTION E8

Page E8-2: In Subsection TS-2, the last sentence should read "*The extent to which units were altered* by the Project were computed.".

Page E8-5: In Subsection E8.42, the last sentence should read "This process of combining terrain units is outlined in greater detail in Section D7 of this *EIA as the macro-terrain units were used in the Ecological Land Classification (ELC) analysis*".

Page E8-8: In Table E8-1, within the Closure Landscape column and footnotes, all references to superscript [c] should be deleted.

Page E8-15: In Table E8-3, all references to superscript [a] and [b] should be removed from the table and footnotes. A new footnote [a] should be applied to "Disturbed Lands" and added to the footnotes section as "[a] roads and other unreclaimed areas".

Page E8-17: The heading Reclamation Soils Capability Class in Table E8-4, should be "*Land Capability for Soil Ecosystems*".

Page E8-17: In Table E8-4, the first column, Muskeg Dumps[a] should have superscript [b] not [a]. Disturbed Lands [c], delete [c]. Footnotes [a] should read "Area will be covered by reclamation soil mixture". Also, footnote [c] should be deleted entirely.

Page E8-18: Under the Soils heading, the fifth line should read ". . . some of the mineral *material* will be. . .".

SECTION E8 (cont'd)

Page E8-18: Under the Soils heading, on the 11th line, the parenthesis should read "(both organic and *mineral*)".

Page E8-19: Table E8-6 should contain another row at the end of the table, as follows:

soils capability class 5	Negative	High	Local	Long-term	Irreversible	Low	N/A

Page E8-19: Key Question TS-3 should read "Will the Reclamation of the Landscape for the Muskeg River Mine Project Change *Land Capability?*".

Page E8-19: In Subsection E8.8.1, the second line of the second paragraph, should read ". . . that occur naturally *(i.e., undisturbed by the Project activities) and* reconstructed soils use for the reclaimed landscape".

Page E8-22: The fourth line of the last paragraph should read "Most prominent is the conversion of 3,279 ha of non-productive class 4 and 5 lands to *low productivity* class 3".

Page E8-23: In Table E8-9, Plant Site in Column 3, Capability Class, should read "*3*". Footnote [(a)] should read "*Reclamation soil mix will be applied*".

Page E8-24: In Subsection E8.8.4, the last paragraph should read "Reclamation and conversion of approximately 28% of the area in the LSA from non- to *low productivity* status . . .".

SECTION E9

Page E9-13: The second paragraph should read "occupying areas of 106 ha, 21 ha, 878 ha and *8 ha* of the LSA respectively. . .".

Page E9-14: The third sentence of the second paragraph should read "The greatest area of clearance within the Project (development) area is associated with ecosite phase d1 (Low Bush Cranberry, *Trembling Aspen*) where . . .".

Page E9-27: In Section E9.9.2, the formula for the Shannon Index on the fourth line of the second paragraph should have a k and $I = 1$ added to bottom and top of the *Sum* symbol.

Page E9-35: In Table E9-18, under the far right column "Change from Pre-Disturbance Conditions Area (ha)", the first row listing for "a1" should read "*-49*". The ninth row listing for "d2" should read "*-1067*".

SECTION E10

Page E10-12: The first paragraph should read "*Thirteen* ecosites were found. . .".

SECTION E10 (cont'd)

Page E10-19: In Table E10-6, the degree of concern for all swamp types should read "*High*".

Page E10-19: In Table E10-6, the far right hand column, eighth cell (for open non-patterned graminoid fen [Fong]), should read "*Moderate*".

Page E10-24: The formula for the Shannon Index on the fourth line of the second paragraph should have a *k* and *I = 1* added to bottom and top of the *Sum* symbol.

SECTION E11

Page E11-11: The second bullet should read "Plant tissue quality data summarized in Section E11.8 and *Appendix X.7*".

Page E11-20: Figures E11-6 to E11-8 should be ignored. These figures are presented later in the Section as Figures E11-13, E11-15 and E11-19.

Page E11-48: Under the Validity of Linkage heading, the last sentence in the first paragraph should read "*Moose habitat will be reduced by 7% (over and above impacts from clearing) . . .*".

Page E11-62: Table E11-8 contained incorrect values. A revised version of this table is provided in Attachment 5 at the end of the AEP information responses.

Page E11-67: Table E11-9 contained incorrect values. A revised version of this table follows. The revised values are shown in italics.

Table E11-9 – Revised: Exposure Ratio Values for Water Shrew and Killdeer

Receptor/Chemical	ER for Invertebrate Diet	ER for Water Ingestion (Muskeg River)
Water Shrew		
Barium	2.26	0.0005
Cobalt	0.44	no data[a]
Copper	1.24	0.000009
Manganese	1.49	0.00005
Zinc	0.35	*0.000006*
Killdeer		
Barium	0.22	0.0004
Chromium	1.63	0.0004
Cobalt	0.31	no data[a]
Copper	0.15	*0.00001*
Zinc	1.43	0.00023
(a) Future predictions of cobalt in the Muskeg River were not available, but evidence suggests ER values would be similar to those predicted for other metals.		

SECTION E11 (cont'd)

Page E11-71: The first bullet is missing. It should read:

- *Muskeg River Mine Project (baseline chemical concentrations; Figure E11-14);*

Page E11-82: Table E11-12 contained incorrect values. A revised version of this table is provided in Attachment 5 at the end of the AEP information responses.

Page E11-96: Table 11-15 contained incorrect values. A revised version of this table is provided in Attachment 5 at the end of the AEP information responses.

Page E11-105 to E11-107: All appendix references should be to "*Appendix X.4*".

Page E11-111: Table E11-18 contained incorrect values. A revised version of this table is provided in Attachment 5 at the end of the AEP information responses.

SECTION E12

Page E12-18: In Table E12-3, all US EPA references should be "*US EPA, 1997*".

Page E12-20: The third line of the last paragraph should read "as described in *Appendices X.1 to X.3*".

Page E12-25: The last line of the second paragraph should read ". . . such as intake rates appear in *Appendix X.6.*".

Page E12-25: Table E12-4 contained errors. A revised version of this table follows.

Page E12-25: Table E12-5 contained errors. A revised version of this table follows, with changes marked in italics.

Page E12-33: Under the heading for Particulate Matter (PM), the sixth line of the first paragraph should read "mine site and in the local communities are presented in *Appendix X.6, Table X-44*".

Page E12-33: Table E12-6 contained errors. A revised version of this table follows, with changes marked in italics.

Page E12-38: Table E12-8 contained errors. A revised version of this table follows.

Page E12-46: Table E12-9 contained errors. A revised version of this table follows, with changes marked in italics.

Page E12-49: Table E12-10 contained errors. A revised version of this table follows.

SECTION E12 (cont'd)

Page E12-63: The last line of the third paragraph should read "...are approved in *Appendix X.6*".

Table E12-4 – Revised: Exposure Ratio Values for Swimming Scenario (Muskeg River)

Receptor/Chemical	Operation (2000-2025)	Closure (2030)	Post-Closure (Equilibrium)
Child			
boron	0.0002	0.002	0.0002
cadmium	0.0002	0.0007	0.0002
lead	0.00005	0.0002	0.00005
molybdenum	0.00002	0.008	0.00002
vanadium	*0.00003*	*0.0008*	*0.00003*
Adult			
boron	0.00002	0.0002	0.00002
cadmium	0.00001	0.00006	0.00001
lead	0.000002	0.000007	0.000002
molybdenum	0.000002	0.0007	0.000002
vanadium	0.000002	0.00007	0.000002
Composite			
benzo[a]pyrene	0[a]	0.07	0.0004
benzo[a]anthracene	0[a]	0.02	0.0004
total PAHs	0[a]	0.09	0.0008

[a] No release of benzo[a]pyrene or benzo[a]anthracene is expected during operation of the Project; hence no risk is predicted for these chemicals (ER = 0).

Table E12-5 – Revised: Exposure Ratio Values for Recreational Scenario (Muskeg River)

Receptor/Chemical	Operation (2000-2025)	Closure (2030)	Far future (Equilibrium)
Child			
boron	0.008	0.07	0.01
cadmium	0.007	0.03	0.007
lead	0.002	0.009	0.002
molybdenum	0.0007	0.3	0.0007
vanadium	*0.001*	*0.03*	*0.001*
Adult			
boron	0.003	0.02	0.003
cadmium	0.002	0.01	0.002
lead	0.0003	0.001	0.0003
molybdenum	*0.0003*	*0.1*	*0.0003*
vanadium	*0.0004*	*0.01*	*0.0004*
Composite			
benzo[a]pyrene	0[a]	0.06	0.0007
benzo[a]anthracene	0[a]	0.02	0.0006
total PAHs	0[a]	0.08	0.013

[a] No release of benzo[a]pyrene or benzo[a]anthracene is expected during operation of the Project; hence no risk is predicted for these chemicals (ER = 0).

Table E12-6 – Revised: Exposure Ratios (Sum ER) for Inhalation Pathway

Chemical/Group	Fort McKay		Fort McMurray		Fort Chipewyan	
	Child[e]	Adult[f]	Child[e]	Adult[f]	Child[e]	Adult[f]
Non-Carcinogens						
aldehydes[a]	2.0E-01	*3.8*	*5.8E-02*	*3.9*	2.0E-02	3.6
ketones[b]	2.8E-05	3.9E-04	8.3E-06	3.8E-04	2.8E-06	3.8E-04
aliphatics	*4.2e-03*	*1.1E-01*	*5.7E-03*	*1.0E-01*	*1.7E-04*	*1.0E-01*
aromatics[c]	2.7E-03	*7.2E-02*	*2.6E-04*	*7.1E-02*	*6.8E-05*	*7.0E-02*
PAH non-carcinogenic[d]	3.3E-06	4.6E-05	9.9E-07	4.5E-05	3.3E-07	4.4E-05
Carcinogens						
formaldehyde	6.3E-02	8.6E-01	1.9E-02	8.3E-01	6.3E-03	8.2E-01
acetaldehyde	3.4E-03	4.7E-02	1.2E-03	5.1E-02	3.9E-04	5.1E-02
benzene	1.4E-03	1.9E-02	4.2E-04	1.8E-02	1.4E-04	1.8E-02
PAH carcinogenic[g]	1.8E-04	2.4E-03	5.4E-05	2.4E-03	1.8E-05	2.3E-03
Total Carcinogens [h]	6.8E-02	*9.3E-01*	2.1E-02	9.0E-01	6.9E-03	8.9E-01

(a) modeled as acrolein
(b) modeled as acetone
(c) excludes benzene
(d) ER values for all non-carcinogenic PAHs
(e) denotes a child of 5-11 years for non-carcinogens, and composite resident for carcinogens
(f) denotes an adult who resides in community and works at mine site
(g) ER value for all carcinogenic PAHs combined, using B(a)P toxicity equivalent factors
(h) the sum of all carcinogen Ers

Table E12-8 – Revised: Reduced Sulphides Ambient Air Concentrations (µg/m^3) for Odour Threshold Analysis

pg. E12-41 Table E12-8, replace with the following:

Chemical	Odour Thresholds[a]		Overall Maximum Predicted			Fort McKay			Fort McMurray			Fort Chipeywan		
	Low	High	1 hour	1 day	annual	1 hour	1 day	annual	1 hour	1 day	annual	1 hour	1 day	annual
2,5-dimethyl thiophene			3.69E+00	2.06E+00	7.73E-01	5.42E-01	8.27E-02	9.82E-03	1.76E-01	3.22E-02	8.35E-04	9.79E-02	4.82E-03	2.04E-04
2-ethylthiophene			1.21E+00	6.77E-01	2.54E-01	1.78E-01	2.72E-02	3.23E-03	5.80E-02	1.06E-02	2.75E-04	3.22E-02	1.58E-03	6.71E-05
2-methyl thiophene			2.56E+00	1.43E+00	5.37E-01	3.77E-01	5.74E-02	6.81E-03	1.22E-01	2.24E-02	5.80E-04	6.80E-02	3.34E-03	1.42E-04
3-methyl thiophene			1.27E+00	7.10E-01	2.67E-01	1.87E-01	2.85E-02	3.39E-03	6.09E-02	1.11E-02	2.88E-04	3.38E-02	1.66E-03	7.03E-05
carbon disulphide	2.43E+01	2.31E+04	1.39E-01	7.75E-02	2.91E-02	2.04E-02	3.11E-03	3.69E-04	6.64E-03	1.21E-03	3.14E-05	3.68E-03	1.81E-04	7.67E-06
carbonyl sulphide			2.50E-01	1.39E-01	5.23E-02	3.67E-02	5.60E-03	6.64E-04	1.19E-02	2.18E-03	5.65E-05	6.63E-03	3.26E-04	1.38E-05
di-n-butyl sulphide	8.97E+01	8.97E+01	1.01E+01	5.65E+00	2.12E+00	1.49E+00	2.27E-01	2.69E-02	4.84E-01	8.84E-02	2.29E-03	2.69E-01	1.32E-02	5.60E-04
diallyl sulphide	5.00E-01	1.49E+02	9.10E-01	5.08E-01	1.91E-01	1.34E-01	2.04E-02	2.42E-03	4.35E-02	7.95E-03	2.06E-04	2.42E-02	1.19E-03	5.03E-05
diethyl sulphide	1.77E+01	1.77E+01	1.21E-01	6.75E-02	2.54E-02	1.78E-02	2.71E-03	3.22E-04	5.79E-03	1.06E-03	2.74E-05	3.21E-03	1.58E-04	6.69E-06
hydrogen sulphide	7.00E-01	1.40E+01	9.95E-01	5.56E-01	2.09E-01	1.46E-01	2.23E-02	2.65E-03	4.76E-02	8.69E-03	2.25E-04	2.64E-02	1.30E-03	5.50E-05
isobutyl mercaptan	2.00E+00	2.00E+00	1.23E-01	6.88E-02	2.58E-02	1.81E-02	2.77E-03	3.28E-04	5.90E-03	1.08E-03	2.79E-05	3.27E-03	1.61E-04	6.82E-06
methyl mercaptan	4.00E-02	8.20E+01	3.32E-02	1.86E-02	6.97E-03	4.89E-03	7.46E-04	8.85E-05	1.59E-03	2.90E-04	7.52E-06	8.82E-04	4.34E-05	1.84E-06
n-amyl mercaptan	1.00E-01	1.80E+00	8.38E-01	4.68E-01	1.76E-01	1.23E-01	1.88E-02	2.23E-03	4.01E-02	7.33E-03	1.90E-04	2.23E-02	1.10E-03	4.64E-05
thiophene	2.60E+01	2.60E+01	3.26E-01	1.82E-01	6.84E-02	4.80E-02	7.32E-03	8.68E-04	1.56E-02	2.85E-03	7.38E-05	8.66E-03	4.26E-04	1.80E-05

Note:
[a] Odour thresholds from Ruth (1986).
Exceeds low odour threshold

Table E12-9 – Revised: Exposure Ratio Values for Children and Adults

Receptor/Chemical	Blueberries	Labrador Tea Leaves	Cattail Root	All Plants Combined
Child				
antimony	0[a]	0.02	0[a]	0.02
barium	0.07	0.02	0.007	0.097
boron	0.02	0.003	0.004	0.027
cadmium	0.03	0.001	0.002	0.033
copper	0.003	0.002	0.0003	0.0053
lead	0.03	0.009	0.008	0.047
molybdenum	0.007	0.0003	0.004	0.011
nickel	*0.02*	*0.004*	*0.006*	*0.03*
vanadium	0[a]	0.0002	0.01	0.0102
Adult				
antimony	0[a]	0.003	0[a]	0.003
barium	0.09	0.003	0.001	0.094
boron	0.03	0.0006	0.0007	0.031
cadmium	0.04	0.0002	0.0003	0.041
copper	0.004	0.0003	0.00006	0.0044
lead	0.02	0.0008	0.0007	0.0215
molybdenum	0.009	0.00005	0.0007	0.0098
nickel	*0.02*	*0.0007*	*0.001*	*0.022*
vanadium	*0[a]*	*0.00004*	*0.002*	*0.002*

[a] not detected

Table E12-10 Revised - Exposure Ratio Values for Children and Adults During Operation

pg. E12-49 Table E12-10, replace with the following:

Receptor/Chemical	Water	Fish	Air	Plants	All Sources
Child[a]					
antimony	0.0002	0	0	0.02	0.02
arsenic [b]	3.5		0		3.5
barium	0.008	0.004	0	0.1	0.112
beryllium[b]	1.5		0		1.5
boron	0.008	0	0	0.003	0.011
cadmium	0.007	0	0	0.03	0.037
copper	0.00004	0.002	0	0.005	0.007
lead	0.002	0	0	0.05	0.052
molybdenum	0.0007	0	0	0.01	0.011
nickel	0.0004	0.06	0	0.03	0.09
vanadium	0.001	0	0	0.01	0.011
acetaldehyde [b]	0	0	3.4E-03	0	3.4E-03
aldehydes [c]	0	0	2.0E-01	0	2.0E-01
aliphatics	0	0	4.2E-03	0	4.2E-03
aromatic [e]	0	0	2.7E-03	0	2.7E-03
benzene [b]	0	0	1.4E-03	0	1.4E-03
formaldehyde [b]	0	0	6.3E-02	0	6.3E-02
ketones [d]	0	0	2.8E-05	0	2.8E-05
PAH non-carcinogenic [f]	0	0	3.3E-06	0	3.3E-06
PAH carcinogenic [b]	0	0	1.8E-04	0	1.8E-04
Total Carcinogenic	*5.0E+00*	*0*	*6.8E-02*	*0*	*5.068*
Adult-Worker [g]					
antimony	0.00007	0	0	0.003	0.003
arsenic [b]	3.5		0		3.5
barium	0.003	0.002	0	0.09	0.095
beryllium [b]	1.5		0		1.5
boron	0.003	0	0	0.03	0.033
cadmium	0.003	0	0	0.04	0.043
copper	0.00001	0.001	0	0.004	0.005
lead	0.0003	0	0	0.02	0.021
molybdenum	0.0003	0	0	0.0097	0.01
nickel	0.0001	0.03	0	0.02	0.05
vanadium	0.0003	0	0	0.002	0.002
acetaldehyde[b]	0	0	4.7E-02	0	4.7E-02
aldehydes [c]	0	0	3.8E+00	0	3.8E+00
aliphatics	0	0	1.1E-01	0	1.1E-01
aromatic [e]	0	0	7.2E-02	0	7.2E-02
benzene [b]	0	0	1.9E-02	0	1.9E-02
formaldehyde[b]	0	0	8.6E-01	0	8.6E-01
ketones [d]	0	0	3.9E-04	0	3.9E-04
PAH non-carcinogenic[f]	0	0	4.6E-05	0	4.6E-05
PAH carcinogenic [b]	0	0	2.4E-03	0	2.4E-03
Total Carcinogenic	*5.0E+00*	*0*	*9.3E-01*	*0*	*5.93*

(a) the ER values which follow are for a child, except for carcinogens where they apply to a composite resident receptor
(b) denotes a substance with carcinogenic effects
(c) aldehydes modelled as acrolein
(d) ketones modelled as acetone
(e) aromatics exclude benzene
(f) refers to the sum ER for grouped non-carcinogenic PAHs
(g) the ER values which follow are for an adult, except for carcinogens where they apply to a composite resident receptor that works at the mine site

APPENDIX V

Page V-2: In subsection V-1.1.2, the last line of the first paragraph after the first bulleted list should read ". . . streams are largely made up of areas covered with muskeg (*Section D5-6*)".

APPENDIX X

Page X-133: The last sentence in the last paragraph should read "Table *X-44* lists *the carcinogenic PAHs with their corresponding TEFs*".

Page X-138: The last sentence of the first paragraph under the heading "Cobalt", should read " Considering an average body weight and food ingestion rate for cattle of *318 kg and 7.95 kg/day,* this maximum tolerable level was converted to a NOAEL of *0.25 mg/kg-day*".

Page X-138: The last sentence of the third paragraph should read "Considering an average body weight and food ingestion rate for chickens of *1.5 kg and 0.106 kg/day,* this maximum tolerable level was converted to a NOAEL of *0.7 mg/kg-day*".

Page X-139: The last line of the first paragraph should read "Therefore, for the killdeer and grouse, a NOAEL of *0.7 mg/kg-day* was used in the current assessment".

Page X-177: Table X-45 contained errors. The revised rows for Table X-45 follow.

Revised Rows for Table X-45

Chemical	Plant Species	Plant Concentration (mg/kg dry wt)	EDI (mg/kg/day)	ER
Child				
Nickel	blue Lab cattail TOTAL	0.99 0.15 10.9	0.003 0.0000016 0.00012	0.015 0.0038 0.006 0.025
Vanadium	blue Lab cattail TOTAL	nd 0.15 7.16	n/a 0.0000003 0.000078	n/a 0.00023 0.011 0.011
Adult				
Lead	blue Lab cattail TOTAL	0.3 2.9 2.5	0.00013 0.0000059 0.0000051	0.018 0.00083 0.00071 0.019

SECTION F2

Page F2-3: In Table F2-2, The area numbers should be corrected as follows:

- The area where the predicted PAI exceeds 0.25 keq/ha/a increases from 1,500 to *1,800 km²* with the project and increases further to *2,500 km²* with CEA.

- The area where the predicted PAI exceeds 0.50 keq/ha/a increases from 155 to *190 km²* with the project and increases further to *315 km²* with CEA.

SECTION F4

Page F4-9: In Table F4-5, the Perimeter CT Seepage Rates for the Time Snapshots at 2007, 2020 and 2030 should be "*0.0001 m³/s*".

Page F4-9: The first sentence in the second paragraph should read "*. . . will be negligible CT perimeter. . .*".

Page F4-25: The first paragraph and Table F4-22 at the top of the page are duplicated at the bottom of this page and should be removed.

Page F4-25: Table F4-22 is a duplicate and should be deleted.

SECTION F5

Page F5-8: In Table F5-4, the Guideline for zinc should be *"0.05 C, 0.19 A"*.

SECTION F6

Page F6-5: The first sentence in the first paragraph should refer to *"Section F4.4.1*".

Page F6-5: The first sentence in the second paragraph should read ". . . "(Key Question SWCEA-1; *Section F4.4.1*)".

Page F6-8, The third sentence in the second paragraph should refer to ". . .*Figure F5-1*)".

Page F6-15: The first sentence in the ninth paragraph should refer to "*Table F4-22*" only.

SECTION F7

Page F7-2: In Table F7-1, the Total Developed Area hectares should read "*57,139 ha*". The percent should read "*5.4% respectively*".

Page F7-3: In the fifth sentence in the fourth paragraph, "4,482 ha" should read "*4,310 ha*".

SECTION F8

Page F8-5: In Table F8-2, a bracketed entry and superscript should be appended to the Kenzie soil series/map unit in column 1, so it appears as "Kenzie (Muskeg)[(f)]" and an additional footnote added as follows, "[(f)] Kenzie - this soil series was named Muskeg in the LSA to conform with the Alberta soil names file (Golder 1997m)".

Page F8-8: In Table F8-3, the second column from the left, third row from the bottom = Reclaimed, wetland and open water - Baseline - ha, cell is blank, This cell should read "*0*".

Page F8-9: In Table F8-4, column 1, Soils Code, the first entry should read "*Algar*" not 'Alger". Further down Column 1, a bracketed entry and superscript should be appended to the Kenzie soil code, so it appears as "Kenzie (Mus) [(h)]" and an additional footnote added as follows, "[(h)] Muskeg in the LSA".

Page F8-10: Under Residual Impacts and Degrees of Concern, the last sentence in the second paragraph before Table F8-5 should read "*Therefore, at closure, the overall net impact of both the Project and the developments in the CEA scenario will be moderate with a moderate degree of concern.*" The soil capability reference should read "*Leskiw (1996)*".

Page F8-14: In Table F8-8, the last column - Degrees of Concern, the blank cells for Capability Classes 2, 3 and 4 should all read "*Moderate*".

Page F8-16: In Table F8-9, PAI Emissions in the RSA – in the last column (ha/% RSA), the second cell should read "*250,000/23.8*". The third cell should read "*31,500/3.0*".

SECTION F10

Page F10-2: In Table F10-1, Column 7 should be changed from "0.0" to "*0*". Column 9 should be changed from "0.0" to "*0*". Column 7 should be changed from "8.3" to "*8.4*".

Page F10-2: In Section F10.4.1, the first sentence of the third paragraph "...of which 3,344 ha (0.3%)..." should read "...of which 3,344 ha (0.3% *of the RSA*). The second sentence of the third paragraph "A further 51,490 (4.9%)..." should read "*...of which 51,490 ha (4.9% of the RSA)...*".The last sentence of the third paragraph should read "...total disturbances predicted for the RSA is 88,397 ha or 8.4%".

SECTION F10 (cont'd)

Page F10-3: The fourth sentence in the second paragraph should read "Just over ten thousand hectares (10,131 ha or 1.0% of the RSA) of this wetland type has been modified by fire. These recently burned fens and bogs are located to the Southeast of the RSA.". The fifth sentence should read "Graminoid fens and marshes comprise less than 4% of the RSA (Table F10-2)." The first sentence should read "The Project will disturb 3,344 ha or 0.5% of the wetlands in the RSA." Second sentence should read "The combined development will disturb 54,834 ha of wetlands or 5.2% of the RSA." Last sentence should read "...an increase of *78%.*".

Page F10-4: Table F10-2 should be corrected as follows:

- Except 1) Column 12, Row 5, 2, Column 14, Row 16 all should be "*0*".
- Column 12, Row 9 and Column 14, Row 16 should be changed to "*<0.1*".
- Column 4, Row 9 should read "*3.0*".
- Column 12, Row 8 should be "*4.1*".
- Change all "%" should be "*% RSA*".
- Column 9, Row 3 should include "*(ha)*".

Page F10-7: In the second sentence of the second paragraph, "354.7" should be "*354.8*" and "31.2" should be "*31.1*". In the fourth sentence "0.3" should be "*0.4*". In the fifth sentence "0.03" should be "*<0.1*".

Page F10-7: In Table F10-5, the following changes should be made:

- All "<0.0001" and "0.001" should be "*<0.1*"
- Column 5, Row 3 "386" should be "*385.9*"
- Column 4, Row 4 "146" should be "*146.0*"
- Column 4, Row 5 "7923" should be "*7923.0*"
- Column 4, Row 6 "89" should be "*89.0*"
- Column 7, Row 3 "230,528" should be "*230,528.0*"
- Column 7, Row 5 "7923" should be "*7923.0*"
- Column 10, Row 1 ""8,516" should be "*8,516.3*"

SECTION F11

Page F11-5: The second last sentence in the first paragraph should read "However, predicted cumulative concentrations for these chemicals are still less than the *risk-based concentrations and therefore require no further evaluation in the risk assessment*".

Page F11-6: In Table F11-3, the Frequency should read "*Medium*".

Page F11-7: In Table F11-4, the first bullet should read "During the construction phase of the oil sands developments, the combined developments will cause

SECTION F11 (cont'd)

relatively small (*1.2 - 2.9%* of the RSA) losses of wildlife habitat due to site clearing and disturbance".

SECTION G2

Page G2-4: Table G2-2: The area numbers should be corrected as follows:

- The area where the predicted PAI exceeds 0.25 keq/ha/a increases to *4,200 m²* with RDR.
- The area where the predicted PAI exceeds 0.50 keq/ha/a increases to *975 km²* with RDR.

SECTION G4

Page G4-9: Table G4-10 was missing from the application. This table has now been supplied at the end of the DFO information responses.

SECTION G5

Page G5-6: In Table G5-4, the Guideline for zinc should be "*0.05 C, 0.19 A*".

SECTION G6

Page G6-2: The last sentence in the second paragraph should refer to "*Section F6.4.1*".

Page G6-4: The first sentence in the second paragraph should refer to "*(Section F5.4.4)*". The first sentence in the third paragraph should refer to "*(Section G4.3.1)*".

Page G6-6: The first sentence in the first paragraph should refer to "*(Section G4.3)*". The first sentence in the second paragraph should refer to "*(Water Quality Section G5.3.3)*". The third sentence in the second paragraph should refer to "*(Figure G5-1)*".

Page G6-7: The first sentence in the second paragraph should refer to "*(Section F6.4.1)*". The third sentence in the seventh paragraph should refer to "*(Section F6.4.1)*".

Page G6-8: The third sentence in the second paragraph should read "As discussed in *Section F6.4.1*)". The seventh paragraph should read ". . . as for the CEA (see *Section F6.4.1*)".

SECTION G6 (cont'd)

Page G6-9: The second paragraph should refer to "(*Section F6.4.1*)."The first sentence in the eighth paragraph should refer to "*Table F4-22*" only.

Page G6-11: The second paragraph should refer to "*Section F6.4.1*." The first sentence in the fourth paragraph should refer to "(*Section F6.4.2*)".

Page G6-12: The first sentence in the first paragraph should read "As discussed in *Section F6.4.3*". The first sentence in the second paragraph should refer to "*(Section F6.4.4)*".The third sentence in the second paragraph should refer to "*Section F6.4.4*" only.

SECTION G7

Page G7-4: In Table G7-2, "Athabasca" should read "Athabasca *Clearwater River Valley*".

SECTION G8

Page G8-3: The superscripts in Table G8-1 should be corrected as follows:

- "Impact [(c)]"
- "RDR [(d)]"

The footnotes should be corrected as follows:

- [(b)] NWL - open water, rivers, streams and lakes
- [(c)] Impact - Incremental changes.
- [(d)] existing footnote [(c)] text is correct, superscript should be changed

In Column 2, the blank cell in the fourth row from bottom - Reclaimed Wetland and Open Water should read "*0*".

Page G8-4: The footnotes in Table G8-2 should be revised as follows:

- [(a)] McLelland in LSA.
- [(b)] Muskeg in LSA.
- [(c)] Undeveloped, developed and reclaimed areas.
- [(d)] NWL - open water, rivers, streams and lakes.
- [(e)] Undeveloped, developed and reclaimed areas.
- [(f)] Incremental changes.
- [(g)] Total impacts from Project, Approved Projects and disclosed developments does not include Forestry as operations do not impact soils.

In Column 1, a bracketed entry and superscript should be appended to the Kenzie soil series, so it appears as "Kenzie (Mus)[(b)]"and an additional footnote added as

SECTION G8 (cont'd)

noted previously. Under Changes From Baseline, CEA, % column, second row from the bottom, the cell entry should read "*-2.4*" not "0-2.4".

Page G8-5: The first sentence of the paragraph following Table G8-3 should read "At closure, the residual impacts would be off-setting in a quantitative sense, hence the final impact and degree of concern would be *Moderate*".

Page G8-6: In Table G8-4, Column 1, Row 6 should read "*AIM* [(e)]"and Row 7 should read "*NWL* [(f)]".

The following footnotes should be added:

- [(e)] AIM - undeveloped, developed and reclaimed areas
- [(f)] NWL - open water, rivers, streams and lakes

Page G8-7: In Table G8-5, Rows 3, 4, and 5 in the last column are blank. These cells should all read "*Moderate*".

Page G8-9: In Table G8-6, the last column - RDR, both ha values are wrong and should read as follows:

- 420,000/40.0
- 98,000/9.3

Page G8-9: In Table G8-7, the Degree of Concern should read "*Moderate to High*".

Page G8-9: The sentence following Table G8-7 should be changed to reflect this also, (i.e., "High" becomes "*Moderate to High*").

MUSKEG RIVER MINE PROJECT
Information Request

EUB No.	Exhibit No.
Information Requested By: EUB	
Date of I.R. June 12, 1998	

Question No. 1

Shell No. EUB 1

Issue **Application Process Issues**

Request 1.1 Provide a project update that includes any relevant information that Shell may have regarding the Muskeg River Mine Project. Include information on: the range of parameters to be examined by the pilot plant that was approved in December 1997 and how those parameters apply to this application, the 1997/1998 drilling program, and a review of the project alternatives.

Response 1.1 A Project Update is included in Sections 1-5 of this Supplemental Information.

Request 1.2 Shell stated that site preparation will need to start in early 1999 and that one of the key project approval decision points is that it receive regulatory approvals and permits before the end of 1998. Describe the impacts to the Muskeg River Mine project if the approvals and permits are not received by the end of 1998.

Response 1.2 Shell and BHP have committed to preparing an investment proposal for their boards of directors in early 1999. In order to invest in the Muskeg River Mine, the joint venture partners will need to know that both the Muskeg River Mine and the Scotford Upgrader have received regulatory approval and that any significant conditions to be applied to the projects are known. These conditions will also have to be evaluated to determine the impact on project approvals.

In its preliminary disclosure in early 1997, Shell set out a project schedule that allowed two years to complete the EUB decision process, beginning with preparation of the EIA terms of reference during the first quarter of 1997. This schedule was prepared after a review of previous application decision processes and consultation with regulatory staff and other stakeholders. On this basis, Shell and BHP committed over $120 million to complete the process development, project development and project front-end engineering design work. The goal was to obtain sufficient engineering definition to allow an investment decision to be made and project execution to proceed immediately afterwards. If Shell had believed that this regulatory schedule was not attainable, the commitment to front-end engineering design would have been deferred.

Shell is seeking separate approvals for the Muskeg River Mine and the Scotford Upgrader and wishes to have the flexibility to sell or purchase upgrading feedstocks depending on operating circumstances and market conditions prevailing at the time. However, as noted in Volume 1, Section 13.1 of the application, the two projects are impacted by the market factors for bitumen. Historically, bitumen–light crude differential values have fluctuated widely. The Muskeg River Mine will provide feedstock for the Scotford Upgrader at predictable cost and quality and the Scotford Upgrader will provide an assured market for the Muskeg River Mine production. Approvals for both projects are required before an investment decision can be made on either.

Shell believes that its proposals for the Muskeg River Mine and the Scotford Upgrader are fundamentally sound and will make significant technical and economic contributions to increasing the value of Alberta's natural resources. Moreover, through the process of application preparation, consultation with stakeholders and responding to information requests from EUB, AEP and DFO staff and others, Shell believes that it has made adjustments to its projects and responded to all significant matters, so that the EUB is now in a position to make an informed decision on the Muskeg River Mine.

Both Shell and BHP compete for capital with their affiliated companies, which have worldwide investment opportunities. Funds must be attracted within the context of global investment plan determination. The investment must be assessed on the basis of technical and commercial strength and ability to execute the projects on a timely basis to return economic value to shareholders. Loss of a schedule milestone, or worse, a protracted delay of a regulatory decision, would increase the risk that the boards of the joint venture partners will lose interest in proceeding with the projects.

Question No. 2

Shell No. **EUB 2**

Issue **Application Process Issues**

Request

Shell stated that the ability to process third party ore provides an opportunity to supplement production for brief periods of time, and that with the emergency ability to transport intermediate process streams over long distances, the potential exists for moving material between area operators.

Clarify Shell's intent for importation of ore and intermediate products. Discuss the feasibility of any options and the implications to the Muskeg River energy and material balances.

Response

The ability to process third-party ore, or more probably froth, at the Muskeg River Mine processing facilities will provide the ability for Shell and BHP and neighbouring operations to take advantage of production opportunities as they arise. The project is being planned for self-sufficiency in generating feedstock for extraction and froth processing facilities. However, it is likely that imbalances will occur within the operation from time to time that could lead to opportunities for profitable exchanges. Ore exchange would be feasible for short durations, but only for operations in close proximity. Froth exchange is more practical over greater distances.

Any such exchanges would be reported annually to the EUB and any implications to mine plans, such as small changes to tailings plans, would be included in future mine plans, which are reviewed by EUB staff.

Exchanges would only be done if both parties found it profitable. As the EUB is aware, 60% of net profits from oil sands operations flows to governments through taxes and royalties. The flexibility to manage production imbalances should provide for more consistent recovery of the resource base and, therefore, enhance revenue streams to both the companies involved and the province.

Given the preceding, Shell sees no need for impeding or placing a regulated limit on exchanges.

Question No. **3**

Shell No. **EUB 3**

Issue **Application Process Issues**

Request 3.1 Explain the statement "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." (Vol. I, p. 1-2). Clarify Shell's intentions to market bitumen. Describe the range of bitumen volumes that may be marketed and describe how an upgrader that received deasphalted bitumen would obtain any benefits, such as reducing CO_2 emissions or increasing final product yield, by using this product.

Response 3.1 Other bitumen producers are free to market their production to third parties and ship it in blends through common carrier or other transportation outlets without restrictions or downstream reporting. Shell is simply requesting that the Muskeg River Mine be treated no differently. Shell intends to build sufficient upgrading for the Muskeg River Mine and fully intends to upgrade production. However, it might be profitable to market some of the bitumen product as a blend if a small surplus can be produced or is available, such as during an upgrader turnaround. Petroleum markets are dynamic, so Shell would respond to opportunities as they arose from circumstances in the operations and the marketplace. As the markets are not definitive, the benefits cannot be quantified. Also, Shell is not in a position to have third-party purchasers provide such information.

Potential purchasers of Muskeg River Mine bitumen would see varying degrees of benefit, depending on their specific process configuration. The unique features are reduced solids, asphaltenes, metals and water-soluble salts. Current surface-mined bitumen production contains about 1% mineral solids. The treated bitumen from the Muskeg River Mine will contain about 0.1% solids.

Qualitatively, treated bitumen has a number of properties that make it a more desirable feedstock than current Athabasca bitumen production. For example, treated bitumen has:

- reduced asphaltene, so the CCR content is reduced by more than 15%
- about 25% less nickel and vanadium
- reduced water soluble salts (particularly chlorides) as a result of the lower water

content in the treated dilute bitumen

- less than 0.1% mineral solids, compared to more than 1%

These properties make it a more desirable feedstock for a residue conversion process. The hydroconversion process can achieve higher conversion levels or reduced catalyst consumption and produce a residue with lower ash content. Cokers will produce less coke with a lower level of ash content.

Request 3.2 Discuss the impacts of solvent losses through the direct marketing of bitumen.

Response 3.2 Paraffinic solvent would be recovered and an alternative diluent provided from natural gas condensate or from upgrader or refinery production.

Question No. 4

Shell No. EUB 4

Issue **Mining Issues**

Request Itemize the unit costs and explain the equation used to define the economic pit limits shown on Figure 4-3. (Vol. I, p. 4-14)

Response The detailed unit cost economic pit limits were established using a combination of the following criteria:

- cut-off stripping ratio
- TV/BIP of 12 (bcm:bcm)
- economic criteria and mining costs
- other factors, such as:
  - geological confidence
  - average ore grade
  - infrastructure location
  - environmental impacts

The unit costs and economic criteria used in establishing the economic mining limits are consistent with existing oil sands operations, and are proprietary.

Calculations used to establish the final pit limits are:

Cut-off strip ratio:

$$SR = \frac{w}{o}$$

Total volume to bitumen in place:

$$TV/BIP = \frac{SGB \times (w + o)}{o \times SGO \times G}$$

Economic line:

$$X = \frac{M \times (o + w) + E \times (o \times SGO)}{P} + F$$

Where:

SR	=	strip ratio (bcm:bcm)
w	=	waste (bcm)
o	=	ore (bcm)
SGB	=	specific gravity of bitumen (t/m^3)
SGO	=	specific gravity of ore (t/m^3)
G	=	bitumen grade (wt%)
M	=	average mining cost ($/bcm)
E	=	average extraction cost ($/t)
P	=	recovered bitumen (bbl)
F	=	average fixed cost ($/bbl)
X	=	economic value ($/bbl)

Question No. **5**

Shell No. **EUB 5**

Issue **Mining Issues**

Request

The proposed mine area limits do not conform with the outlines shown on Figure 4-3 (Vol. I, p. 4-14). What flexibility is there to optimize final pit limit geometry and position especially within the plant site area?

Response

The proposed mine pit limit conforms with the criteria used. However, these limits will be subject to continual refinement and optimization as more detailed mine planning and geological assessments continue. No major changes are expected.

Although no substantial changes to the final pit limit geometry are expected near the plant site, necessary refinements will be made to reflect any minor changes in geological or geotechnical interpretations resulting from new information.

Question No.	6
Shell No.	EUB 6
Issue	**Mining Issues**

Request

What flexibility is there to reduce the size of the plant site proposed?

Response

The plant site is located in an area of low economic potential close to the mining operation. The size of the site will be optimized during detailed engineering and construction.

Shell does not believe that there will be any substantial change to the size of the proposed plant site.

Question No.	7
Shell No.	EUB 7
Issue	**Mining Issues**

Request 7.1 What cut-off grade is Shell requesting during mine start-up, and for what duration?

Response 7.1 Shell is requesting an 8% cut-off until full bench is established (after about two years), and a 7% cut-off thereafter.

Request 7.2 Provide justification in terms of average ore qualities, estimated recovery efficiencies and length of time required.

Response 7.2 Shell proposes a standard cut-off grade of 7% for the Muskeg River Mine. Exceptions to this criteria will be dealt with in mine plans submitted to the EUB. Shell notes that the EUB has examined cut-off grade in a number of circumstances that are similar to those of the Muskeg River Mine. For example, in Decision 97-13, the EUB noted that 8% could be appropriate for the initial period of operation for Syncrude's Aurora Mine. Shell is faced with similar circumstances, in that the initial production will come from the upper benches, which have lower bitumen content. In addition, it is vital for Shell and BHP, with no alternative source of production, to maximize the initial period of production. Therefore, Shell requests that the cut-off grade be 8% for the Muskeg River Mine until production is established on the lower benches. This is expected to occur after about two years of production.

Question No. 8

Shell No. EUB 8

Issue **Mining Issues**

Request Shell's TV/BIP evaluation shows potential exclusion areas within the mine limits.

8.1 Why has Shell included these uneconomic areas in the mine plan and material balance tables (Vol. 1, p. 4-36)?

Response 8.1 Geological modeling shows some minor areas of TV/BIP greater than 12 within the mine area. Mine plans currently include these areas in the mining reserves and production schedule (see Volume 1, Table 4-1, Page 4-3), and the tailings mass balance.

TV/BIP is based on a vertical calculation on the 100 m × 100 m geological block model. It is used as one of several indicators of economic ore to help establish the final pit limits.

If mining operations were to exclude the small areas of TV/BIP greater than 12, the effect of bench slopes and berms would reduce the overall TV/BIP of the remaining island from the original vertical estimate.

Based on current geological understanding, the inclusion of these areas in the mining reserves is expected to have a minor impact on mining economics.

Further geological definition will assist with detailed mine and tailings planning around these areas.

Request 8.2 Discuss the impacts of leaving these areas unmined.

Response 8.2 Based on current geological understanding, Shell does not believe that significant exclusion areas will be found within the mining area.

If such exclusion areas were to be defined during mining operations, appropriate alterations to mining plans would be proposed and agreed on with the EUB. No significant impact on mining, extraction or tailings operation is expected.

Question No. 9

Shell No. EUB 9

Issue **Mining Issues**

Request 9.1 Discuss how Shell intends to recover ore at shared lease boundaries. Include in the discussion: any agreements between Shell and Syncrude that would guarantee complete recovery, information about the shared risk and liability for failure for a common dyke, and any intentions to leave an ore wedge at the lease boundary to enhance in-pit dyke stability.

Response 9.1 Shell is currently working with Syncrude to develop an agreement for mining ore at lease boundaries (see Section 3.4, Lease Boundary Management, in the Project Update).

Request 9.2 Provide four copies of 8 1/2" by 11" cross-sections through these common areas showing the final in-pit dyke profiles for both Syncrude and Shell.

Response 9.2 See Figure 3-4 in Section 3.4 (Lease Boundary Management) in the Project Update.

Question No. 10

Shell No. EUB 10

Issue **Mining Issues**

Request What cut-off grade is Shell requesting during mine start-up, and for what duration? Provide justification in terms of average ore qualities, estimated recovery efficiencies and length of time required.

Response See the response to EUB 7.

Question No. 11

Shell No. EUB 11

Issue **Mining Issues**

Request 11.1 Provide four sets of working scale representative perpendicular sections through the crusher area showing ore and waste zones, grade, final pit wall slopes and equipment.

Response 11.1 See Section 2.5 (Supplementary Illustrations) in the Project Update for 8 1/2" by 11" cross-sections through the crusher area. Further details are provided in working-scale sections, which are available in digital format, on request.

Request 11.2 Explain why the ore below elevation 245 cannot be stockpiled and mine waste used to backfill to the crusher pad elevation.

Response 11.2 See Section 3.2 (Resource Estimates) in the Project Update.

Request 11.3 Also provide Shell's estimate of the sterilized reserve and ore quality below the crusher pad.

Response 11.3 See Section 3.2 (Resource Estimates) in the Project Update.

Question No. **12**

Shell No. **EUB 12**

Issue **Mining Issues**

Request Shell refers to a Dyke 7 (Vol. I, p. 4-29), however the mining mass balance given in table 4-9 (Vol. I, p. 4-36) does not include Dyke 7. Provide an updated table which accounts for this dyke.

Response Dyke 7 is incorrectly referenced. The material is placed in Cell 6 and is accounted for in the mass balance in Volume 1, Table 4-9, Page 4-36).

Question No. **13**

Shell No. **EUB 13**

Issue **Mining Issues**

Request Provide four sets of 1:20,000 scale maps of the project development sequence shown on Vol. I, p. 16-49 to 16-62 and add the year 2016 to this package. In-pit dykes and oversize reject disposal areas must be labeled. A CD ROM graphics file may be requested.

Response See Section 3.6 (Supplementary Illustrations) in the Project Update.

Oversized reject has no specific disposal location. It will be hauled and dumped as part of the overburden and tailings disposal plan.

The disposal of the oversized reject is shown in Volume 1, Table 6-5, Page 6-26.

Question No.	**14**
Shell No.	**EUB 14**
Issue	**Mine Waste Disposal Areas**

Request

Shell should be aware that additional questions may arise concerning mine waste disposal areas resulting from the submission of the 1997/98 drilling results. Explain why the West Disposal Area and the reclamation stockpile cannot be moved to the northwest to take full advantage of the northwest-trending waste channel and reduce resource sterilization.

Response

The west disposal site is located in an area of low economic potential (see Section 3.2 (Resource Estimates) in the Project Update for estimates of resource sterilized). The northern extent of the dump is limited by the geotechnical setback to the mine, the Susan Lake gravel pit and the Aurora access corridor. As detailed mine planning continues, Shell will minimize the impact on ore sterilization in the final design of the west disposal area.

The west reclamation material stockpile is temporarily located near the initial opening, so no resource will be sterilized.

Question No.	**15**
Shell No.	**EUB 15**
Issue	**Resource Definition**

Request

15.1 Based upon a TV/BIP less than or equal to 12.0, provide: the average ore grade, recoverable bitumen volume, overburden volume, TV/BIP, TV/NRB, and waste to ore ratio for each disposal site, reclamation stockpile and the Tailings Areas 1 and 2.

Response

15.1 See Section 3.3 (Tailings Settling Pond) in the Project Update.

Request

15.2 Estimates of sterilized reserves must consider a geotechnical set-back distance and appropriate final pit wall geometries to produce a sterilization halo surrounding each disposal site and corridor.

Response

15.2 See Section 3.3 (Tailings Settling Pond) in the Project Update.

Request

15.3 Each estimate area must be referenced from a results table to a working scale plan showing the areas corresponding to the reserve values. A site layout and the sterilization set-backs should also be shown on the plan.

Response 15.3 See Section 2.5 (Supplementary Illustrations) in the Project Update.

Request 15.4 Include representative 8 1/2" by 11" cross-sections, as required, to clarify geometry assumptions.

Response 15.4 See Section 3.2 (Resource Estimates) in the Project Update.

Question No. 16

Shell No. EUB 16

Issue Resource Definition

Request

Provide four sets of working scale cross-sections showing ore and waste zones, grade quality, rivers, surface facilities and pit walls for the following Nad 27 co-ordinates. Also include section locations and reference number on the TV/BIP contour map requested.

Section 1 West – East at 6,349,700N from 470,600E to 476,500E
Section 2 West – East at 6,349,300N from 470,600E to 476,500E
Section 3 6,348,300N, 470,200E to 6,344,850N, 474,500E
Section 4 6,347,100N, 469,850E to 6,344,150N, 473,750E
Section 5 6,347,400N, 468,300E to 6,343,050N, 473,300E
Section 6 West – East at 6,345,900N from 463,400E to 475,000E
Section 7 West – East at 6,344,400N from 464,000E to 474,000E
Section 8 West – East at 6,343,500N from 464,000E to 471,000E
Section 9 North – South at 465,000E from 6,345,000N to 6,340,000N
Section 10 North – South at 465,850E from 6,346,300N to 6,340,000N
Section 11 6,344,600N, 463,100E to 6,341,600N, 467,750E

Response

See Section 2.5 (Supplementary Illustrations) in the Project Update. An electronic copy of these maps is available, on request.

Question No. 17

Shell No. EUB 17

Issue Resource Definition

Request

Provide four sets of the following Lease 13 contour maps, at 1:20,000 scale, which includes the 1997/98 drilling information and outlines of all surface facilities, corridors, pit limits and rivers.

a. Overburden isopach, interburden isopach, waste to ore ratio and insitu or diluted ore grade.

b. A zone optimized TV/BIP contour map with a contour range of 4.0 to 18.0, a contour interval of 2.0, drill hole locations and ID numbers. Show the limits of the Shell/ Syncrude common mining areas.

c. A basal aquifer isopach map.

Response

See Section 2.5 (Supplementary Illustrations) in the Project Update. An electronic copy of these maps is available, on request.

Question No. 18

Shell No. EUB 18

Issue Muskeg River Resources

Request

Using the criteria defined in question 15, provide the average ore grade, recoverable bitumen volume, overburden volume, TV/BIP, TV/NRB, and waste to ore ratio for the ore sterilized along the final pit wall between the proposed plant site and 6,347,800 N.

Response

Potentially economic resource beneath the Muskeg River is not easily quantified. The lateral influences of the river and its environmental setback limits are subject to many interpretations, which are too numerous for discussion and evaluation in this response.

The geotechnical characteristics of consolidated tailings, settling time, and in situ geological conditions will impact the amount of resource sterilized along the pit wall.

Resource estimate details are provided in Section 3.2 (Resource Estimates) in the Project Update, based on the conceptual geometry shown in Figure 18-1.

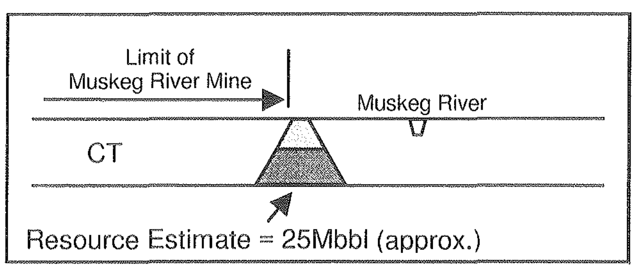


Figure 18-1: Conceptual Geometry

Question No.	**19**
Shell No.	**EUB 19**
Issue	**Muskeg River Resources**

Request 19.1 How does Shell intend to recover the resources under the Muskeg River?

Response 19.1 As the EUB is aware, Shell's application does not include the recovery of resources under the Muskeg River. Shell's current mine plan is as described in its application and the potential impact of the current mine plan on potentially recoverable ore under the Muskeg River is described in the response to EUB 18. The information requested by the EUB is more appropriately the subject of a future application. If Shell made such an application it would, at that time, provide all relevant information for recovering the resources under the Muskeg River if it were environmentally and socially acceptable. Shell does not have the information requested as it is not relevant to its current application.

As the EUB is also aware, the fate of the Muskeg River is a significant issue to the local and regional development east of Shell's proposed development. An evaluation of mining through the Muskeg River would more properly be undertaken as part of that broader regional review. Finally, and as the EUB is also aware, an evaluation of recovering the resources under the Muskeg River and relocating the Muskeg River cannot be done on the cursory basis suggested without involving significant input from all stakeholders. The information requested by the EUB would be only a small part of a very comprehensive review of this controversial issue in a potential future application.

Request 19.2 Provide details of the options evaluated including plan views and working scale cross-sections which illustrate the relocation options considered for the Muskeg River.

Itemize the project capital required for the river relocation options and list the details to clarify the increased area for the tailings settling pond (Vol. I, p. 4-15).

Response 19.2 Options for relocating the Muskeg River are discussed in the application (see Volume 1, Section 4.2, p. 4-15), and these options are still available for independent future development.

No detailed cost evaluations were undertaken for relocating the river to determine economic viability.

Request 19.3 Include a discussion of the environmental impacts of mining through the river versus leaving 100 metres of undisturbed buffer, the long term viability of the Muskeg River considering cumulative hydrological impacts in the region, and the schedule risks.

Response 19.3 See the response to EUB 19.1.

Request 19.4 If there were no schedule risks, and relocation of the Muskeg River was solely dependant on capital costs, would Shell consider relocation of the river to be economically viable?

Response 19.4 See the response to EUB 19.1.

Question No. **20**

Shell No. **EUB 20**

Issue **Muskeg River Resources**

Request

Shell intends to place CT into in-pit cells 1 and 2 so that the tailings would lie directly against the final pit wall along the Muskeg River. Due to the non-homogeneous nature of insitu oil sand, it is possible that the width of the required pillar between mining areas east and west of the river would be governed by the requirement to contain the saturated tailings rather than by offsets from the river.

20.1 What analysis has Shell done to determine the minimum pillar width required to contain the tailings?

Response 20.1 The Muskeg River Mine tailings plan requires CT to be deposited in containment cells constructed using dykes and the east pit wall. Shell has not performed any detailed geotechnical or hydrological assessment of a pillar that might be formed from mining through the Muskeg River from the eastern side. Such a study would require detailed analysis, and is outside the scope of the Muskeg River Mine application. The geotechnical characteristics of consolidated tailings cannot be accurately estimated or modeled until further field tests and operational experience can be drawn upon. The CT deposits will acquire strength over time, which should minimize the impact on recoverable resource.

Shell acknowledges the EUB's concerns about potential resource being sterilized by consolidated tailings deposited against pit walls, and commits to continuing research into tailings technology to provide a better understanding of key characteristics.

Request 20.2 Has Shell considered constructing a compacted barrier between the CT in cells 1 and 2 and the final pit wall to reduce the required dimensions of any pillar required to allow future mining beneath the Muskeg River?

If such a barrier is not compacted, what other actions might Shell take to reduce the influence of the CT on resource recoverability?

Response 20.2 Shell considered constructing a barrier along the east wall of the Muskeg River Mine, but no detailed evaluations were done. The design of such a barrier would require significant understanding of the geotechnical characteristics of consolidated tailings, and speculative assumptions on the timing and conditions of any future mining from the east side.

Directionally, the impacts of placing any fill along the east wall will be present, whether the fill is compacted or loose dumped. Some of the impacts are that:

- the rate of dyke construction would be affected as a result of the additional material being redirected to the barrier fill
- the void for CT in Cell 1 would be consumed by the barrier fill
- additional external tailings would be required to accommodate the loss of Cell 1 volume
- additional capital operating costs would be incurred as a result of increased external tailings and barrier fill construction costs

The volume of material required in any barrier fill is subject to detailed design, operational and resource recovery constraints. To release 100% of the ore for future east side development, a minimum barrier fill of 150-200 m would be required. This represents 35-50 Mbcm of material to construct the barrier, and a loss of similar volume to the Cell 1 containment for CT.

From this directional analysis, Shell concludes that the concept is impractical and has dropped it from consideration at this preliminary stage.

Question No. **21**

Shell No. **EUB 21**

Issue **Tailings Site Alternatives**

Request Shell indicated that Tailings Area 1 has an economic advantage of over $800 million (on a net present value basis) over Tailings Area 2 (Vol. I, p. 4-9). Provide a copy of the complete screening study completed for Tailings Area 2, and include a site plan of Tailings Area 2.

Response The screening level cost analysis has been updated (see Section 3.3, Tailings Settling Pond in the Project Update). Tailings Area 2 has not been designed. Therefore, a site plan cannot be provided. Tailings Area 2 is located in the southeast corner of Lease 13. See Volume 1, Section 4.2, Figure 4-2.

Question No.	**22**
Shell No.	**EUB 22**
Issue	**Tailings Site Alternatives**

Request

Provide an economic evaluation of the ore beneath Tailings Area 1 which estimates the future resource value if Tailings Area 2 were used and compare this future resource value against the additional cost of Tailings Area 2.

Response

The in situ resource (at TV/BIP less than 12) sterilized by the tailings settling pond is estimated to be between 28 million m^3 (174 Mbbl) and 33 million m^3 (206 Mbbl) (see Section 3.2, Resource Estimates, in the Project Update). The resource is characterized by intermittent tidal channel sands (see Section 2.4, Disposal Areas, in the Project Update). The potential mining of this resource would require a significant change to the operational strategy of the proposed Muskeg River Mine, because:

- the resource is less attractive than mining Areas 1 and 2 (see Volume 1, Table 3-6, p. 3-17) on the west side of the lease because of lower grade and higher TV/BIP
- the tailings settling pond would have to be located at the southeast side of the lease at Site 2, which would increase the cost of all bitumen production from the Muskeg River Mine because of the increased distances and elevation
- the average ore thickness is low because of the absence of fluvial ore. This would result in increased surface area to be disturbed and reclaimed for each cubic metre of bitumen produced
- the average ore grade is lower than the average for the proposed Muskeg River Mine, which would increase recovery and tailings concerns
- the geological nature of the ore is complex and might require smaller and more selective mining equipment at increased operating cost

Applying a range of typical full-cycle mining, extraction and tailings costs provides an indication of the economic potential of the ore sterilized by the tailings settling pond, as follows:

• mining (waste and ore)	\$3.00/bcm to \$3.50/bcm
• extraction	\$3.00/t to \$4.00/t
• tailings Location 2	\$0.80/bbl
• fixed overheads	\$0.30/bbl
• break-even cost	\$10.70/bbl to \$13.30/bbl

The ore sterilized by the tailings settling pond is of extremely low economic potential, and would probably not be developed until post 2035.

In addition, releasing this ore for development would necessitate the use of Tailings Location 2 for the start-up operation. This would result in unnecessary additional costs, thereby reducing the overall economic potential of all ore on the west side of Lease 13.

Question No.	**23**
Shell No.	**EUB 23**
Issue	**Tailings Management**

Request

What work has Shell done to show that the CT deposition plan will work when operational difficulties have been experienced by other operators?

If operational difficulties proved unmanageable what contingency plans would Shell implement to mitigate the impacts?

Response

The mass balances recognize inefficiencies in CT production that are accounted for in the total annual volumes of solids and water to be handled.

If CT performance fell outside the allowances, increased volumes could be placed in the out-of-pit pond. The pond height could be increased to accommodate greater out-of-pit volumes without adversely affecting the recycle water quality.

Question No.	**24**
Shell No.	**EUB 24**
Issue	**Tailings Management**

Request

24.1 Explain the in-pit tailings design sensitivities completed by Shell and their impacts. For example, in-pit dyke slopes in excess of 4:1 and beach slopes less than 5 per cent.

Response

24.1 In-pit and out-of pit tailings volumes are managed in tandem. Therefore, design contingencies must consider the two together.

Historical Beach Angles:

The tailings plan takes into account that the ore particle size distribution on Lease 13 is similar to that at Suncor where, historically, overall beach angles of about 5% have been achieved. The overall 3% cited by the EUB is representative of Syncrude's Mildred Lake ore.

Beach above water (BAW) slopes are typically 0.5 to 0.6 times flatter than beach below water (BBW) slopes. The slope angles used tend to represent the overall angle considering the blend of BAW and BBW operations. Actual placement results in a varying deposit angle between the discharge point and the pond edge.

Application Design:

The detailed layout of the application case considered the annual rise of the tailings settling pond structure. In order to fit the tailings sand into the available overall footprint, it was necessary to use a design with a split beach, by stepping-out hydraulic-fill construction using a 0.5% slope. The 5% slope angle then begins at the end of the 0.5% zone. The net effect for the overall beach angle is flatter beach.

Table 24-1 shows conditions in a typical section through 2005. By about 2008, an overall beach slope of 5% is approached. This results from less sand being available as a result of in-pit CT manufacture which begins in 2006.

From a design perspective, slope angles in the early years of operation tend to be more critical than in later years when other options are available. Because slope angles tend to flatten with height, the angles achieved are initially greater.

The relative elevation of the pond to the crest and original ground (or toe of beach) controls the relative amount of BAW to BBW. This ratio is reported in Table 24-1. Assuming a scenario where the pond was encroaching on the freeboard because of a lack of beach, there is a tendency to self-correct as the overall beach angle achieved will increase.

Beach angles and compacted cell requirements (see EUB 25) are key design premises as they determine the sand available to retain pond fluids. As noted in the response to EUB 23, the height of the out-of-pit pond could be increased.

Table 24-1: Typical Cross-Section Geometry

Year End	Cell Elevation (m)	Pond Elevation (m)	Ratio Height of BAW/BBW	Freeboard (m)	Overall Beach Angle (%)
2002	297	294	0.33	3	3.1
2003	306	302	0.23	4	4.3
2004	313	304	0.57	9	4.3
2005	319	310	0.36	9	4.5

Request 24.2 What excess in-pit capacity is there and what contingencies and flexibilities has Shell examined?

Response 24.2 Contingencies can be obtained in the form of steeper slopes, or alternatively, by using other approaches.

Steeper slopes can be achieved by changing the tailings deposition method to increase the number of discharge points by using spigots. Modifying the tailings density in the transport lines and controlling discharge velocity are also possible. All of these methods result in higher costs for facilities and operations.

The current design incurs a pinch point at about 2008. If beach angles are significantly flatter than 5%, there will be insufficient beach to support cell construction using an upstream method. The alternative would be to step cell construction further out onto beaches in earlier years and construct a more centreline type cross-section. This would allow the pond to directly abut compacted cells, and beach would not be required for cell support.

Question No. 25

Shell No. EUB 25

Issue **Tailings Management**

Request

25.1 Explain the out-of-pit tailings design sensitivities completed by Shell and their impacts. For example out-of-pit dyke slopes in excess of 4:1, larger compacted cell widths, 3 per cent beach slopes, less than 35 per cent sand capture within compacted cells.

Response

25.1 For dyke slopes, see the response to EUB 24.

For sand capture, 35% for compacted cell construction is a standard industry practice and is, therefore, considered achievable. Shell acknowledges that cell building operations in the field need to be carefully managed to achieve this level.

The total sand cell volume and beach sand volumes used in mass balance calculations, assuming 35% sand requirement for pond construction before CT production in 2005, are reported in Volume 1, Table 6-4. For detailed design, the final required sand captures are reported in Table 25-1. Only the start-up year (2002) exceeds 35%, at 39%. The second year requires 30% and all other years are at 20 to 23%. The high capture used for the first year is driven by the need to eliminate further costs for additional overburden-based construction.

The overall tailings mass balance in Volume 1, Table 6-4 was not adjusted to account for the reduced cell requirement shown in Table 25-1.

Table 25-1: Achieved Annual Cell Volumes

Year	Annual Available Sand (Mm^3)	Annual Cell Sand (Mm^3)	Total Sand (%)
2002	22	8.5	39
2003	44	13.0	30
2004	43	8.5	20
2005	43	8.5	20
2006	32	6.5	20
2007	24	5.0	21
2008	24	5.0	21
2009	24	5.0	21
2010	13	3.0	23
2011	9.6	2.0	21
2012	5.3	1.0	19

Request	25.2	What excess out-of-pit tailings capacity is there and what contingencies and flexibilities has Shell examined?
Response	25.2	In-pit and out-of-pit capacities are managed in tandem. See the responses to EUB 23 and 24.

Question No. 26

Shell No. EUB 26

Issue **Tailings Management**

Request	26.1	Under paste technology, will Shell evaluate the concept of thickening only the fines and not the entire tailings stream (Vol. I, p. 5-24)?
Response	26.1	Shell has entered into a cooperative arrangement with Syncrude and Suncor that will provide for sharing technical information to pilot, develop and commercialize tailings management techniques involving paste and CT technologies. Included will be information on the use of thickeners to partially de-water fines. Shell does not consider the use of thickeners to be an economic alternative to the use of a tailings settling pond and the application of CT in providing a dry reclaimable land surface. Shell believes that there are other means of recovering process heat from tailings streams, such as heat exchangers, which might be more cost effective than recycling water from a thickener.
Request	26.2	What options are available for separating the tailings produced in the product clean-up phase from the tailings produced from the solids removal stage so that the asphaltenes can be stored separately, thus reducing the amount of hydrocarbon material in the tailings pond?
Response	26.2	The tailings from the product clean-up phase are combined with the tailings from the solids removal phase to enable solvent to be recovered through a single tailings solvent recovery unit. Shell will continue to evaluate options for handling the tailings from the product clean-up phase. However, the current proposed disposition of the product clean-up tailings in the tailings settling pond and subsequent containment in the CT deposits in the mined areas offers an environmentally acceptable and cost effective option.
Request	26.3	Include a discussion on the toxicity of the asphaltenes and any breakdown products.
Response	26.3	Asphaltenes represent a small amount (about 0.3 wt%) of the total tailings stream going to the tailings settling pond. Therefore, their inclusion will have only a minor effect on the chemistry of the full tailings stream. Laboratory extracted samples of

asphaltenes from oil sands show this material to be very low in PAH and leachable metals. PAHs were only detectable in a few of the samples tested and none was present at concentrations greater than 2.4 μg/g

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Question No. 27

Shell No. EUB 27

Issue **Tailings Management**

Request Shell indicated that the asphaltenes would be disposed of with the normal tailings stream. Has the additional volume from the asphaltenes been included with the tailings volumes given in table 6-5 (Vol. I, p. 6-24 through 6-26)? If not, update table 6-5 to include the asphaltenes.

Response Because the volume of the asphaltenes is minimal (about 0.3 wt% of the total tailings stream), it was not included as a separate line item in Volume 1, Table 6-5. Its influence on the overall tailings balance is insignificant.

Question No. 28

Shell No. EUB 28

Issue **Tailings Management**

Request Shell indicated that the fallback closure plan for handling MFT is to create a water-capped MFT lake (Vol. I, p. 6-11).

28.1 Discuss the changes that would be required to the proposed final landscape if the fallback plan were to be implemented.

Response 28.1 Shell is confident that CT or other methods of capturing fine tailings within the sand tailings deposits can be made to work at the performance levels assumed in the application.

Water capping is a technology that is useful for end-pit lakes for relatively small residual volumes of mature fine tailings (MFT). Water capping the total MFT volume is considered a remote contingency and, therefore, no detailed plans have been completed. If it were implemented, increased out-of-pit volumes and in-pit volumes could be created to avoid increased resource sterilization. This would be accomplished by increasing the elevations of the out-of-pit pond, as well as some areas of the in-pit backfill, in order to retain additional void volume in the final in-pit lake for MFT.

Request 28.2 Will Shell continue to investigate dry tailings techniques?

Response 28.2 See the response to EUB 26.1.

Question No. 29

Shell No. EUB 29

Issue Extraction Issues

Request Although Shell committed to achieving a primary extraction recovery of 94 per cent five years after initial start-up (using rotary breakers, agitation tanks, an extraction temperature of 50°C, and no caustic process additives), the impacts of using the technologies listed above have not been adequately addressed.

29.1 What options are available if the recovery can not be met?

Response 29.1 As noted in the response to EUB 32, rotary breakers and agitation tanks are features of the Steepbank Mine, which will come on stream during 1998. This will provide adequate time for Shell to respond to any performance shortfalls.

If there is a shortfall in recovery because there are no process aids, Shell could selectively add caustic or use flotation additives. As discussed in EUB 37, Shell also has access to the low energy extraction (LEE) process technology from Syncrude and is assessing it for the Muskeg River Mine.

Request 29.2 What are the impacts to the energy, mass and tailings balances of the options?

Response 29.2 A preliminary assessment of the application of the 25°C LEE process at the Muskeg River Mine would be a 33% saving in fuel consumption. No substantive change would be made to the tailings and mass balance.

Question No. 30

Shell No. EUB 30

Issue Extraction Issues

Request Would Shell accept a condition in its approval requiring a bitumen recovery of 93 per cent from primary extraction, 98 per cent from froth treatment and 96 per cent from product cleanup, and an expectation to report on efforts to improve recovery every year, or alternatively, after 5 years be expected to meet a bitumen recovery of 94 per cent from primary extraction?

Response Shell will commit to a recovery of 91% overall through froth treatment. This is similar to recoveries approved by the EUB in recent decisions for other operators. Notwithstanding this commitment, Shell would recommend that the EUB use a set of recovery resource parameters that reflect best practice, and ore grade, rather than using a single recovery target.

The current estimate is for a 4% rejection of asphaltene hydrocarbon. Shell does not consider this to be a bitumen loss, but rather a step toward upgrading bitumen. The rejection rate is still being examined for optimization through the front-end engineering and design phase with downstream processing. Optimization to enhance overall upgrading will continue throughout the life of the operation.

Question No. 31

Shell No. EUB 31

Issue **Extraction Issues**

Request Based on the numbers shown in table 4-7 (Vol. I, p. 4-27), there is no increase in production throughout the life of the project. If production were increased through debottlenecking, discuss the potential impacts to the material and energy balances for the mine and the extraction plant.

Response In Volume 1, Table 4-7 provides a nominal production rate for initial design purposes. Shell fully intends to look for debottlenecking opportunities and does not wish to be constrained by a particular production limit. Shell requests the EUB to provide in its decision on the application, the flexibility to increase production over and above the nominal production rate to ensure that debottlenecking opportunities are not impeded as long as operating performance criteria are met.

If production were increased through debottlenecking, it would result in an acceleration of mining. The material and energy balances would increase accordingly. A debottlenecking program would also be accompanied by parallel efforts to increase service factor and process efficiency. Such a debottlenecking program would be based on assessing operating performance, then determining the selected areas of investment to increase overall plant output. Although it is difficult to predict at this stage how the balances might vary from a straight linear extrapolation, economic impacts from the project would be more positive and there would be no substantive change to the environmental impacts.

Question No. 32

Shell No. EUB 32

Issue **Extraction Issues**

Request The information on slurry preparation and the material balance indicates low oil sands reject losses through the use of rotary breakers. Describe what actions Shell can take if losses in rejects were significantly higher than indicated in the material balance.

Response Shell is confident that rotary breakers can be used to achieve low reject oil losses. Shell will have access to Suncor's commercial operating performance from the Steepbank Mine. This information will become available during 1998 and 1999 as part of the start-up of the Steepbank operation. This timing will allow the information to be available as input to Shell's commercial design engineering. If Suncor's experience indicates that reject oil losses are higher than expected in a commercial plant, the design characteristics of the rotary breakers would be re-evaluated. Remedial actions, such as adding an additional breaker on the reject stream or recycling reject through the rotary breakers, could also be considered. If it were determined that a satisfactory level of reject losses could not be attained, then alternative technologies could be evaluated. Access to Suncor's commercial experience should provide adequate time to take remedial action, if necessary.

Question No. **33**

Shell No. **EUB 33**

Issue **Extraction Issues**

Request Agitation tanks for conditioning of oil sands are new technology.

33.1 Provide an update on how oil sands conditioning in the agitation tanks can be controlled.

Response 33.1 Agitation tanks have general application in the mineral and coal processing industries. They are used for liquid storage, slurry preparation and surge control ahead of pipelining. Their application to oil sands is new. The first application is in progress for Suncor's Steepbank Mine Project. Shell has worked with Suncor in developing the application for oil sands and will be able to access data from this commercial operation during the design stage of the Muskeg River Mine facilities.

Oil sand conditioning is influenced by retention time, mechanical shear energy, temperature and slurry density. Each of these can be varied with the use of agitation tanks. Retention time can be controlled by varying the flow rate and level of slurry within the tank. Mechanical shear energy can be controlled by varying the mixer speed and impeller design. Temperature and slurry density can be varied during slurry preparation ahead of the agitation tank.

Request 33.2 Discuss the impacts for various oil sand grades, and the effects on process control, bitumen recovery, and froth quality.

Response 33.2 The work carried out at CANMET in 1997 indicated that the use of agitation tanks to condition oil sands of various grades achieved bitumen recoveries comparable to existing commercial operations without the use of caustic. This work is summarized in a technical paper entitled *Bitumen Release Mechanisms and New Process Development* being presented by CANMET at the UNITAR conference in Beijing, China, in November 1998.

The pilot plant on Lease 13 will be used to confirm the results obtained by CANMET and for developing commercial control philosophy.

Request 33.3 Describe what actions Shell can take if this technology does not operate as expected.

Response 33.3 Shell believes that agitation tanks can be commercially applied in oil sands operations. Hydrotransport of oil sands is an alternative approach to oil sand conditioning that has been successfully used by Syncrude and is being used in conjunction with agitation tanks at Suncor's Steepbank Mine. Shell has arrangements in place with Syncrude to license hydrotransport as a technology alternative.

Question No. **34**

Shell No. **EUB 34**

Issue **Extraction Issues**

Request The proposal to use nitrogen and a partial vacuum to remove solvent from the secondary tailings stream is significantly different from the technology currently employed to remove diluent from tailings streams.

34.1 What data does Shell have to support the feasibility of this process?

Response 34.1 The tailings solvent recovery process has been designed on standard engineering practice and is based on flashing the residual solvent from the tailings using nitrogen (or methane) with a partial vacuum. Because there is no operating experience with the blend of mineral solids and hydrocarbon in the tailings, the process performance will be confirmed in the pilot operation.

Request It is Shell's intent to cool the solvent and return it to tankage for continued use in the process.

34.2 Discuss how Shell intends to handle any other hydrocarbons that may be recovered along with the solvent in both the tailings solvent recovery unit and the solvent recovery unit.

Response 34.2 An equilibrium trace quantity of bitumen distillate will be contained in the circulating paraffin solvent at the Muskeg River Mine operation. However, some of the diluent will remain in the diluted bitumen for pipeline shipment. No net bitumen product will be recovered in the solvent recovery unit at the Muskeg River Mine operation.

Question No. 35

Shell No. EUB 35

Issue **Extraction Issues**

Request

Shell appears to have used the product clean-up stage as the final stage of its extraction process for the energy balance. Update Shell's extraction energy balance to show the balance at the end of the centrifuge stage.

Response

The revised energy balances are provided in Section 4.3 (Material and Energy Balances) in the Project Update.

Question No. 36

Shell No. EUB 36

Issue **Extraction Issues**

Request

What is the feasibility and impact of changing the temperature of the paraffinic froth treatment process to aid in improving bitumen recovery and tailings solvent recovery?

Response

The small-scale paraffinic froth treatment piloting at CANMET indicated that increasing process temperatures might increase the overall recovery of bitumen in a single-stage mixer and settler arrangement. The impacts of higher process temperature on product quality and processability of the underflow from the single-stage mixer and settler arrangement are still under investigation. Shell proposes to use a multiple arrangement of mixers and settlers with increased solvent ratios in some settlers to obtain acceptable recovery and product quality without the need for increased process temperatures.

The ability to increase process temperature (e.g., in the range of 80 - 140°C) is feasible and would require additional energy input. Increasing process temperatures will require modifications to the process vessels to contain increased vapour pressures. These modifications would result in additional cost.

The solvent composition, solvent to bitumen ratio and operating temperature of the separation process are being studied and optimized for process design. Bitumen recovery, solvent recovery and the selectivity of the asphalt rejection step are the key process performance characteristics to be considered. The precise operating conditions are considered proprietary.

Question No.	**37**
Shell No.	**EUB 37**
Issue	**Extraction Issues**

Request

Shell stated in the process comparisons that the current state of development of low temperature processes is not sufficiently complete to allow them to be considered as the preferred option (Vol. I, p. 5-25). What information has Shell to base this decision on?

Response

When Shell selected its process scheme and the process parameters under which the scheme would operate, field and research piloting of low temperature processes was not complete. Shell has subsequently entered into an agreement with Syncrude to access research and pilot data on its low energy extraction (LEE) process for evaluation purposes. Shell has the option to license this technology from Syncrude and also to license aspects of the technology from the Alberta Government.

The application of low temperature bitumen extraction processes, such as the LEE process, has only reached the field pilot stage. There are no commercial operations in place which operate at process temperatures lower than 50°C.

Shell's process configuration will allow lower process temperatures to be implemented if they provide a more economic means of producing a bitumen product of acceptable quality. Shell is continuing to evaluate lower extraction process temperatures as an alternative.

Question No.	**38**
Shell No.	**EUB 38**
Issue	**Utilities Issues**

Request

Shell stated that "a utility corridor that runs southwest from the plant site to the lease boundary and then west for connections to:" (Vol. I, p. 1-5)

38.1 Describe how the services listed in the bullets that follow the statement will cross the Athabasca River to reach the Muskeg River Mine site.

Response

38.1 See Section 4 (Utilities and Infrastructure) in the Project Update for the status of development for utilities and offsites.

In the Muskeg River Mine application, a utility service corridor was considered that would have two 144 kV transmission lines for connection to the Alberta electrical grid, natural gas supply, communication networks and links, and a connection to Highway 63. Several options are currently being pursued for electrical power, natural gas and communication infrastructure. Some arrangements will not be finalized until late 1998 or early 1999. Any related regulatory approvals that are required will be sought then.

Request 38.2 Include in the discussion an update on any dialogue with potential third party operators.

Response 38.2 See Section 1.2 (Regional Cooperation) and Section 4.1 (Utilities and Offsites) in the Project Update.

Question No. 39

Shell No. EUB 39

Issue Utilities Issues

Request 39.1 Discuss the advantages and disadvantages of regional power generation alternatives versus on site power generation alternatives.

Response 39.1 The primary benefit of on-site power generation is the efficiency of cogeneration in conjunction with thermal energy requirements. These cogeneration efficiencies could potentially be attained for bitumen mine operations either on a separate basis or on a shared basis with neighbouring operations. Sharing thermal and electrical generation facilities has the potential benefit of economies of scale. This benefit would have to be weighed against the cost of pre-investment and pre-commitment to larger facilities in advance of their need as well as any costs for integrating between facilities that are physically separated. Regardless of whether facilities are shared, regional electrical generation reliability can potentially be enhanced through sharing arrangements for back-up power support. A key issue in any decision concerning on-site power generation is the assessed cost of power generation using purchased natural gas as an energy source versus the potential pricing in the marketplace for purchased electricity.

Request 39.2 Include any discussion between Syncrude and Shell on the benefits of integrating heat and power generation for the Aurora North and Muskeg River mines.

Response 39.2 See Section 4.1 (Utilities and Offsites) in the Project Update.

Question No. 40

Shell No. EUB 40

Issue Utilities Issues

Request Based on the plant design rates given in the application, only 50 million m^3/a of water are required to produce 23,850 m^3 of bitumen, not the 80 million m^3/a requested. Provide information why Shell requires approval to withdraw 30 million m^3/a more than required (based on a stream day).

Response

The rate of 50 million m^3/a (or 5,772 m^3/h) of process water is required on a calendar day basis to produce 23,850 m^3/d of bitumen. Additional water is required for gland water, boiler feed water and potable water. This additional water brings the required annual average (calendar day) requirement to 55 million m^3/a or 6,284 m^3/d, as shown in Volume 1, page 8-13. Similarly, 8,560 m^3/d or 75 million m^3/a is required on a stream day basis. The additional 570 m^3/d or 5 million m^3/a to bring the total rate to 80 million m^3/a is required for flush water and any other uses not accounted for, such as water for dust suppression in the mine and for cleaning mobile equipment.

The requirement of 80 million m^3/a is an instantaneous (stream day) rate of withdrawal and might be better defined as a withdrawal rate of 9,144m^3/h, and not the annual average water withdrawal requirement of 55 million m^3/a.

Question No. **41**

Shell No. **EUB 41**

Issue **Utilities Issues**

Request

Table 8-3 (Vol. I, p. 8-36) shows a water balance summary for average conditions.

41.1 Describe the impacts to water withdrawal if the amount of water released from CT is plus or minus 10 per cent of the average volumes.

Response

41.1 The water withdrawal rate (5,950 m^3/h or 52.1 million m^3/a) in 2003 (the year with the maximum average water requirement) was estimated based on average inflow conditions, when there will be no CT water releases (see Volume 1, Table 8-3, Page 8-36). Therefore, a 10% change in CT water releases will not affect the water withdrawal rate of 6,284 m^3/h (55 million m^3/a) applied for. For future years (e.g., 2017, the year with the maximum CT water releases), a 10% decrease in CT pore water releases might change the water withdrawal rate by about 700 m^3/h. This increased withdrawal rate would only represent about 11.5% of the withdrawal rate applied for.

Request

41.2 Explain why the recycle water in Figure 8-3 is different than in Figure 8-18 for the year 2008.

Response

41.2 In Volume 1, Figure 8-3, the Total Recycle Water (36.7 million m^3) was calculated as being the sum of the volumes given in Table 8-3 for the following:

- net runoff
- CT porewater recycle and CT pit runoff
- basal aquifer depressurization
- MFT porewater recycle and tailings pond runoff

In Figure 8-18, the sum of the runoff, basal aquifer, net evaporation, tailings pond recycle and CT in-pit recycle is the same as the volume of total recycle water (36.76 million m^3) presented in Figure 8-3.

Table 41-1 compares the two sets of data for 2008.

Table 41-1: Water Recycle Components for 2008

Component[1]	Volume (Mm^3/a)	Component[2]	Volume (Mm^3/a)
Net runoff	1.0	Runoff	3.51
CT porewater recycle and CT pit runoff	10.8	CT in-pit recycle	9.41
Basal aquifer depressurization	1.5	Net evaporation	-0.98
MFT porewater recycle	23.4	Basal aquifer depressurization	1.54
		Tailings pond recycle	23.39
Total recycle	36.7	Total recycle	36.87

Notes: 1. From Figure 8-3 and Table 8-3, Volume 1, Section 8.
2. From Figure 8-18, Volume 1, Section 8.

Question No. 42

Shell No. EUB 42

Issue Utilities Issues

Request

To adequately evaluate the hydrocarbon recovery advantage of the Muskeg River Mine and the hydroconversion upgrading scheme in combination, EUB staff require block flow diagrams comparing hydroconversion upgrading to coking processes that includes recoveries, material balances and a discussion of energy efficiency.

Response

The block flow diagram for the Muskeg River Mine with the proposed hydroconversion upgrader is shown in Figure 42-1. Table 42-1 summarizes the mass and energy balance for this configuration.

The original Muskeg River Mine material balances were prepared before some of the initial pipeline and upgrader design bases were established. Consequently, there were inconsistencies between the two submissions on diluent:bitumen ratios in the diluted bitumen and in the densities of treated bitumen. These have been corrected to be consistent with the upgrader for these balances, except for small rounding differences that occur when converting from average annual hourly rates to calendar day rates.

A complete energy balance with a coking upgrader and a conventional froth treatment mine would require that a process design be completed so that fuel and electrical loads could be included as well as having material balances. Shell has not completed such a design. However, mass recoveries can be compared using Figure 42-2 and the associated Table 42-2. Product yields for this coking case are based on the following assumptions:

- SCO yield of 75 wt% on whole bitumen feed
- recovered sulphur of 3.4 wt% on whole bitumen feed
- mining loss adjusted to exclude rejection of asphaltene
- froth treatment diluent losses adjusted to 0.6 vol% of bitumen feed

The mass balance for the conventional froth treatment and coking configuration is shown in Table 42-2.

The total energy efficiency of an upgrader is dependent upon the site-specific opportunities and decisions on fuel and energy integration. For example, factors such as site internal heat recovery and integration, sources of hydrogen and integration or non-integration of hydrotreating will have impacts that might exceed the differences between conversion technology selection. Similarly, there are design choices in a surface mining extraction complex that can alter total energy efficiency beyond simply the choice of processing.

Generic process alternative studies are of value in the initial setting of a project configuration. Total energy efficiency becomes a matter of efficient process design driven by economics.

Shell could prepare a more detailed process study of a coking alternative if the EUB believes that such a study is necessary for a decision. Alternatively, there are a number of process studies available in the public domain that Shell would be willing to provide to the EUB staff to provide greater insight into conversion alternatives.

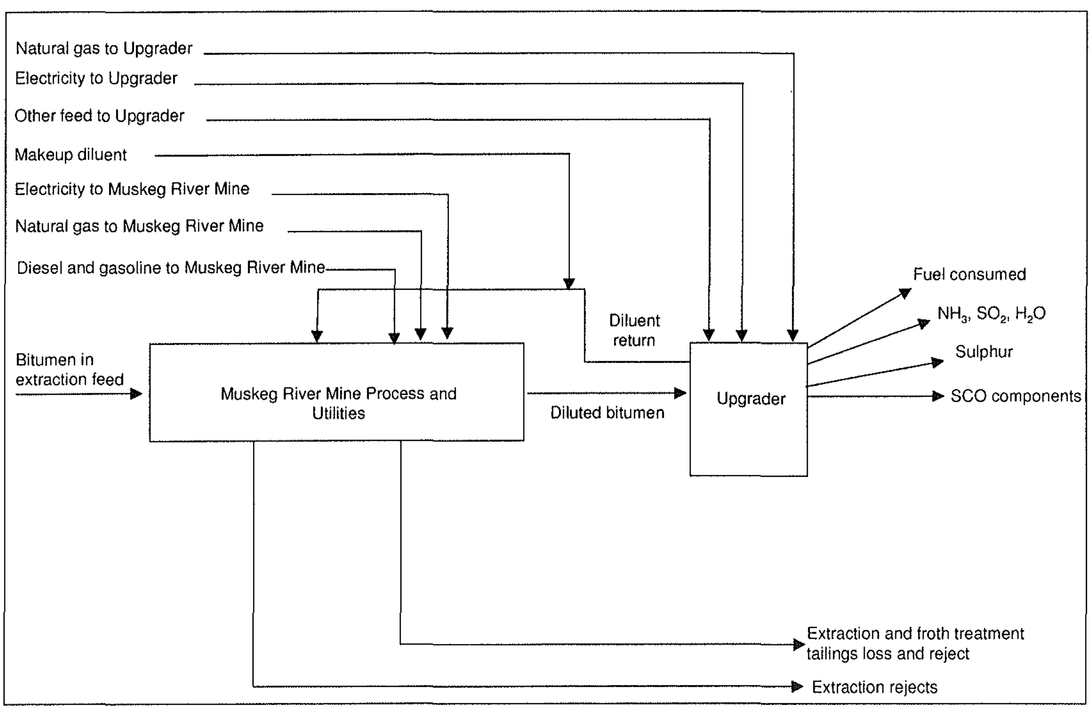


Figure 42-1: Muskeg River Mine Plus Hydroconversion Block Flow

Table 42-1: Muskeg River Mine Hydroconversion Mass Balance

Summary of Inputs	HC-Mass (t/cd)	Energy (GJ/ch)	Summary of Products and Losses	HC-Mass (t/cd)	Energy (GJ/ch)
Bitumen in oil sands to extraction	27,336	44,648.8	SCO components	25,556.1	44,331.4
Natural gas to Muskeg River Mine		1,812	Product sulphur	1,000.9	386.4
Electricity to Muskeg River Mine		291	Upgrader fuel consumed	894.9	1,925.8
Diesel and gasoline to Muskeg River Mine		294	Upgrader NH_3, SO_2, H_2O loss	1,120.5	1,496.6
Natural gas to upgrader	1,395	2,873.2	Extraction reject bitumen loss	48	78.4
Electricity to upgrader		190.2	Tailings bitumen HC loss and reject	3,456	5,028
Other feeds to upgrader	3,047.2	5,244.7	Froth treatment paraffin loss	168	314.09
Paraffin make-up	168	314.09	Natural gas to Muskeg River Mine		1,812
Scotford H_2S	289.7	183.8	Electricity to Muskeg River Mine		291
			Diesel and gasoline to Muskeg River Mine		294
Total	32,235.91*	55,851.79*		32,244.4*	55,957.69*
	Energy conversion (SCO + sulphur)/inputs =			0.80	
	Mass yield = (SCO + Sulphur)/Mass inputs =			0.82	
Note: * Differences result from rounding errors from calendar hour data to calendar day data.					

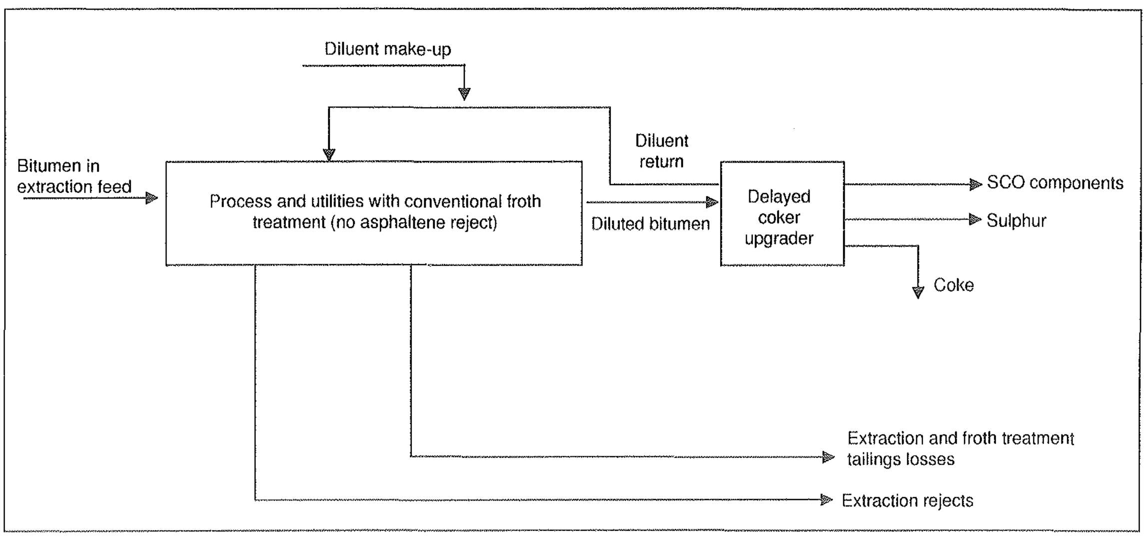


Figure 42-2: Mine with Conventional Froth Treatment and Coking

Table 42-2: Mine - Coker Yields

Hydrocarbon Inputs	t/cd	Hydrocarbon Products and Losses	t/cd
Bitumen in oil sands to extraction	27,336	SCO components	18,638.64
Diluent make-up	98.87927	Product sulphur	844.9517
Total	27,434.88	Coke	4,349.016
		Extraction rejects bitumen loss	48
		Tailings bitumen loss	2,436.48
		Froth treatment diluent loss	98.87927
Mass yield	0.71		

Question No. 43

Shell No. EUB 43

Issue **Environmental Issues – Groundwater**

Request

Analysis of Potential Linkages. "Hydrogeology, however, is not a valid linkage for this CEA. The effects of hydrogeology (i.e., surficial aquifer drawdown) is best assessed on an individual project basis." (Vol. IV, p. 9-2) The conclusion drawn in this statement requires clarification. The hydrogeology of a region, specifically the surficial aquifers, has a very relevant and direct relationship to the terrestrial vegetation and therefore, the linkage would be valid. On a regional scale, explain what the effect(s) of surficial aquifer drawdown may have on terrestrial vegetation, specifically on wetland areas.

Response

Drawdown of the surficial aquifer is restricted to within 1 to 2 km of drainage ditches. As the effects will only be seen within the local study area, this is not considered a cumulative effect for the Muskeg River Mine Project. Cumulative effects are addressed when impacts from other developments and activities overlap on the same resources impacted by the Muskeg River Mine Project.

No cumulative effects would be experienced on terrestrial vegetation and wetlands. The impacts within a 1 to 2 km area surrounding the mine are discussed in EIA Volume 3, Part 1, Section E.10.

Potential cumulative effects on Muskeg River flows are described in EIA Volume 4, Section F4-4 for the cumulative effects assessment (CEA) and in Section G4-3 for the regional development review (RDR).

Question No. 44

Shell No. EUB 44

Issue **Environmental Issues – Groundwater**

Request

44.1 Explain the potential cumulative effects of muskeg and overburden dewatering along with basal aquifer depressuring on wetland and natural drainage stream hydrology and ecosystems.

Response

44.1 See the response to EUB 43. The effect of basal aquifer drawdown on wetlands was interpreted to be negligible, as discussed in EIA Volume 3, Part 1, Section E10. See the response to DFO 39 for additional details on the effect of the basal aquifer drawdown on Kearl Lake and wetlands.

Request 44.2 If drainage and aquifer drawdown for cumulative development adversely affects wetland hydrology, explain the local and regional implications of resulting loss of wetlands.

Response 44.2 Potential cumulative effects on Muskeg River flows are described in EIA Volume 4, Section F4-4 for CEA and in Section G4-3 for RDR.

As surface water hydrology accounted for the effects of dewatering in EIA Volume 4, Sections F4 and G4, the water quality and aquatic effects were also accounted for.

Question No. 45

Shell No. EUB 45

Issue Environmental Issues – Groundwater

Request A number of inconsistencies or discrepancies are noted for the groundwater flow models. These are:

45.1 The models for pit 1 have greatly different thicknesses of compact tailings for the year 2010.

Response 45.1 For 2010, the model for Pit 1, Cross-section 2 has been adjusted to the same CT thickness as Pit 1, Cross-section 1. A revised Figure IV-15 is provided at the end of this section. The corresponding change in seepage to the basal aquifer is negligible.

Request 45.2 The model for pit 5 appears to use a recharge flux which is not sustainable for compact tailings, resulting in hydraulic heads which are 10 to 20 metres above pit level (Figures IV-17 and IV-23). The elevation of the upper surface of mined overburden appears to be incorrectly used in Figures IV-24 and IV-30.

Response 45.2 The recharge flux for the Pit 5, Cross-section 1 models in Figure IV-17 and IV-23 has been adjusted to 6.8e-10 m/s and 6.5e-10 m/s, respectively. The resulting heads are in all cases below ground surface. Revised Figures IV-17 and IV-23 are provided at the end of this section. Changes in seepage to the basal aquifer are included in revised Tables E3-3 and IV-7 at the end of this section.

The elevation of mined overburden in Figures IV-24 and IV-30 has been adjusted to 273 masl. Revised Figures IV-24 and IV-30 are provided at the end of this section. Changes in seepage to the basal aquifer are included in revised Tables E3-3 and IV-7.

The end-pit lake model for the far future, shown in Figure IV-42, has also been revised to include constant head nodes equal to lake elevation, across the surface of the MFT. A revised Figure IV-42 is provided at the end of this section. Changes in seepage to the basal aquifer are included in revised Tables E3-3 and IV-7.

Request 45.3 The Muskeg River constant head node appears to be incorrectly placed for models of Cross-section 1-1. The river appears to be about 3 to 4 metres below the unmined surface and is not laterally connected to the sand, yet the models show seepage to be occurring from the river and into the sand unit, then toward pit 1, all above the water table (Figures IV-1, IV-12, IV-14, IV-18, IV-20 and IV-25).

Response 45.3 The Muskeg River constant head node for Cross-section 1-1 is correctly located. The node is at ground surface and the fixed head corresponds to the assumed elevation of the Muskeg River at that location. However, the precise relationship between the river and the adjacent geological materials is difficult to show at the scale of the diagrams, because the surficial sand thins as ground surface declines in elevation near the river. The constant head node is located at the corner of a triangular element consisting of surficial sand, so there is lateral hydraulic connection with the surficial sand.

Request 45.4 The head at the upper surface of MFT in end pit lake on Figure IV-42 should be equal to the elevation of the water surface.

Response 45.4 Error acknowledged. The head at the upper surface of MFT in the end-pit lake in Figure IV-42 should be equal to the elevation of the water surface.

Question No. 46

Shell No. EUB 46

Issue **Regional Development Issues**

Request Shell stated that it and BHP staff have been working, and will continue to work with Syncrude on location of roads and utility corridors, geological and mine reviews and alignment, lease boundary harmonization, project management and execution awareness on opportunity investigations and infrastructure sharing. Provide an update on the status of each of these points and any changes to the Muskeg River Mine Project as a result of these discussions.

Response See Section 1.2 (Regional Cooperation) and 4.1 (Utilities and Offsites) in the Project Update.

Question No. 47

Shell No. EUB 47

Issue **Regional Development Issues**

Request Shell stated that it, Syncrude and other lease holders with concurrent developments are committed to working together and with the regulatory agencies to develop sensible, effective, integrated mine plans.

	47.1	Provide examples of where this has happened with the Muskeg River Mine Project and the alternatives if cooperation had not been achieved.
Response	47.1	See Section 3.4 (Lease Boundary Management) in the Project Update.
Request	47.2	Explain how closure planning for Shell and Syncrude has been integrated or where there are opportunities for integration.
Response	47.2	Closure planning will be included as an integral part of joint planning between Shell and Syncrude along common boundary areas of the Aurora Mine and the Muskeg River Mine. As noted in Volume 1, Figure 1-7, Oil Sands Development Principles of Cooperation, one of the potential opportunities identified was the *sharing of mine plans and joint mine planning where mining and/or reclamation should be harmonized to ensure efficient resource recovery and reclamation.*

Question No. **48**

Shell No. **EUB 48**

Issue **Regional Development Issues**

Request

Shell indicated that a number of opportunities have been identified between it and Syncrude for cooperation on infrastructure and services and that these will become clearer as the definition and execution plans are developed in 1998.

Provide an update as to what the opportunities are, and how they might be implemented.

Explain why other areas of cooperation have not been achieved, and the impacts on the mine plan and the environment.

Response

Mutual cooperation on mining lease boundaries, routing access corridors, supplying mine fuel, planning electrical transmission and regional system reliability continue to be areas that will bring economic and environmental benefits.

Areas that are no longer being pursued, such as joint electrical generation, were dropped because of a lack of economic incentive or schedule constraints.

Revised Table E3-3 and IV-7 Seepage Discharge From Mine Pits and Tailings Ponds

Snapshot Time	Pit No.	X-Section No.	Total Discharge to Surface Water (m^3/d)	Receiving Stream	Source Material of Discharge	Receiving Surface Water Node	Total Seepage to Basal Aquifer (m^3/d)
2000	1	1-1	NA	NA	NA	S16	NA
Pre-construction Drainage	1	1-2	NA	NA	NA	S16	NA
	2	2-1	NA	NA	NA	S16	NA
	3	3-1	NA	NA	NA	S16	NA
	4	4-1	NA	NA	NA	S32	NA
	5	5-1	NA	NA	NA	S16	NA
	6	6-1	NA	NA	NA	S32	NA
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	NA	NA	NA	S16	NA
	Tailings Pond, W	7R	NA	NA	NA	S17	NA
	Tailings Pond, W	7R	NA	NA	NA	S33	NA
	Tailing Pond, All	7R	NA	NA	NA	NA	NA
2002	1	1-1	-68.8	Muskeg River	Mined Overburden	S16	0
Pre pit opening	1	1-2	-107.5	Muskeg River	Mined Overburden	S16	0
	2	2-1	NA	NA	NA	S16	NA
	3	3-1	NA	NA	NA	S16	NA
	4	4-1	NA	NA	NA	S32	NA
	5	5-1	NA	NA	NA	S16	NA
	6	6-1	NA	NA	NA	S32	NA
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	245.6	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	65.1	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	65.1	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	1540

Revised Table E3-3 and IV-7 Seepage Discharge From Mine Pits and Tailings Ponds (Cont'd)

Snapshot Time	Pit No.	X-Section No.	Total Discharge to Surface Water (m^3/d)	Receiving Stream	Source Material of Discharge	Receiving Surface Water Node	Total Seepage to Basal Aquifer (m^3/d)
2003	1	1-1	-68.8	Muskeg River	Mined Overburden	S16	0
1st Year Prod.	1	1-2	-107.5	Muskeg River	Mined Overburden	S16	0
	2	2-1	NA	NA	NA	S16	NA
	3	3-1	NA	NA	NA	S16	NA
	4	4-1	NA	NA	NA	S32	NA
	5	5-1	NA	NA	NA	S16	NA
	6	6-1	NA	NA	NA	S32	NA
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	374.3	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	72.2	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	72.2	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	1760
2005	1	1-1	-68.4	Muskeg River	Mined Overburden	S16	59
Prod./recycle, no CT	1	1-2	-107.4	Muskeg River	Mined Overburden	S16	60
	2	2-1	-55.3	Muskeg River	Mined Overburden	S16	NA
	3	3-1	NA	NA	NA	S16	NA
	4	4-1	NA	NA	NA	S32	NA
	5	5-1	NA	NA	NA	S16	NA
	6	6-1	NA	NA	NA	S32	NA
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	499.0	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	79.1	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	79.1	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	1964

Revised Table E3-3 and IV-7 Seepage Discharge From Mine Pits and Tailings Ponds (Cont'd)

Snapshot Time	Pit No.	X-Section No.	Total Discharge to Surface Water (m^3/d)	Receiving Stream	Source Material of Discharge	Receiving Surface Water Node	Total Seepage to Basal Aquifer (m^3/d)
2010	1	1-1	-67.2	Muskeg River	Mined Overburden	S16	59
75% of capacity	1	1-2	-106.5	Muskeg River	Mined Overburden	S16	60
	2	2-1	-121.3	Muskeg River	Mined Overburden	S16	0
	3	3-1	0.0	Muskeg River	Mined Overburden	S16	0
	4	4-1	NA	NA	NA	S32	NA
	5	5-1	NA	NA	NA	S16	NA
	6	6-1	NA	NA	NA	S32	NA
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	692.8	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	89.7	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	89.7	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	2253
2022	1	1-1	-63.7	Muskeg River	Mined Overburden	S16	71
Processing complete	1	1-2	-76.5	Muskeg River	Mined Overburden	S16	74
	2	2-1	-38.4	Muskeg River	Mined Overburden	S16	88
	3	3-1	0.0	Muskeg River	Mined Overburden	S16	75
	4	4-1	0.0	NA	Mined Overburden	S32	160
	5	5-1	-93.8	Muskeg River	Recast Tailing Sand	S16	**166**
	6	6-1	0.0	NA	Mined Overburden	S16	0
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	1080.2	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	89.9	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	89.9	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	2484

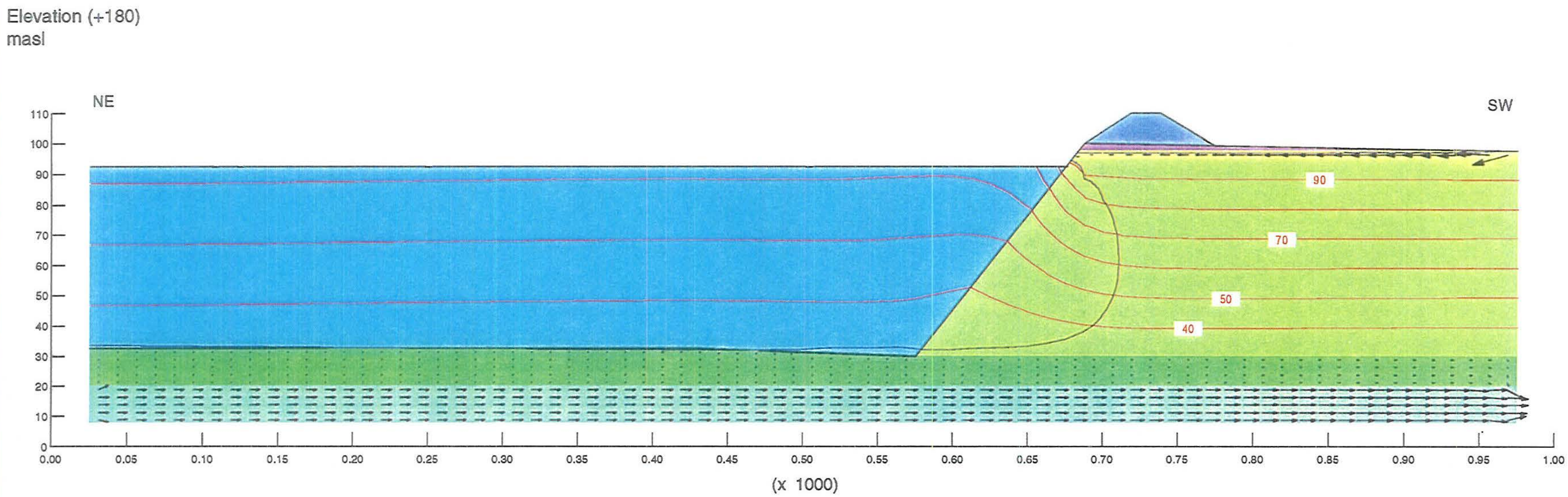
Revised Table E3-3 and IV-7 Seepage Discharge From Mine Pits and Tailings Ponds (Cont'd)

Snapshot Time	Pit No.	X-Section No.	Total Discharge to Surface Water (m^3/d)	Receiving Stream	Source Material of Discharge	Receiving Surface Water Node	Total Seepage to Basal Aquifer (m^3/d)
2025	1	1-1	-63.7	Muskeg River	Mined Overburden	S16	71
Closure in progress	1	1-2	-76.5	Muskeg River	Mined Overburden	S16	74
	2	2-1	-38.4	Muskeg River	Mined Overburden	S16	88
	3	3-1	0.0	Muskeg River	Mined Overburden	S16	75
	4	4-1	0.0	NA	Mined Overburden	S32	160
	5	5-1	-94.7	Muskeg River	Recast Tailing Sand	S16	**174**
	6	6-1	NA	NA	Mined Overburden	S16	**194**
	End-pit Lake	EPL	NA	NA	NA	S32	NA
	Tailings Pond, E	7R	262.7	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	207.7	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	207.7	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	1617
2030	1	1-1	-2.3	Muskeg River	Mined Overburden	S16	36
2nd year after closure	1	1-2	-12.9	Muskeg River	Mined Overburden	S16	39
	2	2-1	8.8	Muskeg River	Mined Overburden	S16	50
	3	3-1	0	Muskeg River	Mined Overburden	S16	47
	4	4-2	-1.8	End-pit Lake	Recast Tailing Sand	S32	167
	5	5-1	-1.9	Muskeg River	Recast Tailing Sand	S16	87
	5	5-2	-1410.9	End-pit Lake	Mined Overburden/Tailings Sand	S32	NA
	6	6-1	NA	NA	Mined Overburden	S16	**192**
	6	6-2	22.1	End-pit Lake	Mined Overburden/Tailings Sand	S32	NA
	End-pit Lake	EPL	0.0	NA	Water	S32	2837
	Tailings Pond, E	7R	262.7	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	207.7	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	207.7	Isadore's Lake	Tailings Sand	S33	NA
	Tailing Pond, All	7R	NA	NA	Tailings Sand	NA	1617

Revised Table E3-3 and IV-7 Seepage Discharge From Mine Pits and Tailings Ponds (Cont'd)

Snapshot Time	Pit No.	X-Section No.	Total Discharge to Surface Water (m^3/d)	Receiving Stream	Source Material of Discharge	Receiving Surface Water Node	Total Seepage to Basal Aquifer (m^3/d)
Far Future	1	1-1	31.0	Muskeg River	Mined Overburden	S16	17
	1	1-2	28.8	Muskeg River	Mined Overburden	S16	17
	2	2-1	15.0	Muskeg River	Mined Overburden	S16	17
	3	3-1	0.0	Muskeg River	Mined Overburden	S16	32
	4	4-2	-6.2	End-pit Lake	Recast Tailings Sand	S32	104
	5	5-1	31.3	Muskeg River	Recast Tailing Sand	S16	68
	5	5-2	-944.4	End-pit Lake	Mined Overburden/Tailings Sand	S32	NA
	6	6-1	NA	NA	Mined Overburden	S16	1285
	6	6-2	6.3	End-pit Lake	Mined Overburden/Tailings Sand	S32	NA
	End-pit Lake	EPL	**10.5**	Isadore's Lake	Water	S33	**557**
	Tailings Pond, E	7R	262.7	Muskeg River	Tailings Sand	S16	NA
	Tailings Pond, W	7R	207.7	Athabasca River	Tailings Sand	S17	NA
	Tailings Pond, W	7R	207.7	Isadore's Lake	Tailings Sand	S33	NA
	Tailings Pond, All	7R	NA	NA	Tailings Sand	NA	1617

Note: NA - Not Applicable
Bold - Revised #s



NOTES

Contours are hydraulic head, (+180 m) asl

Groundwater surface

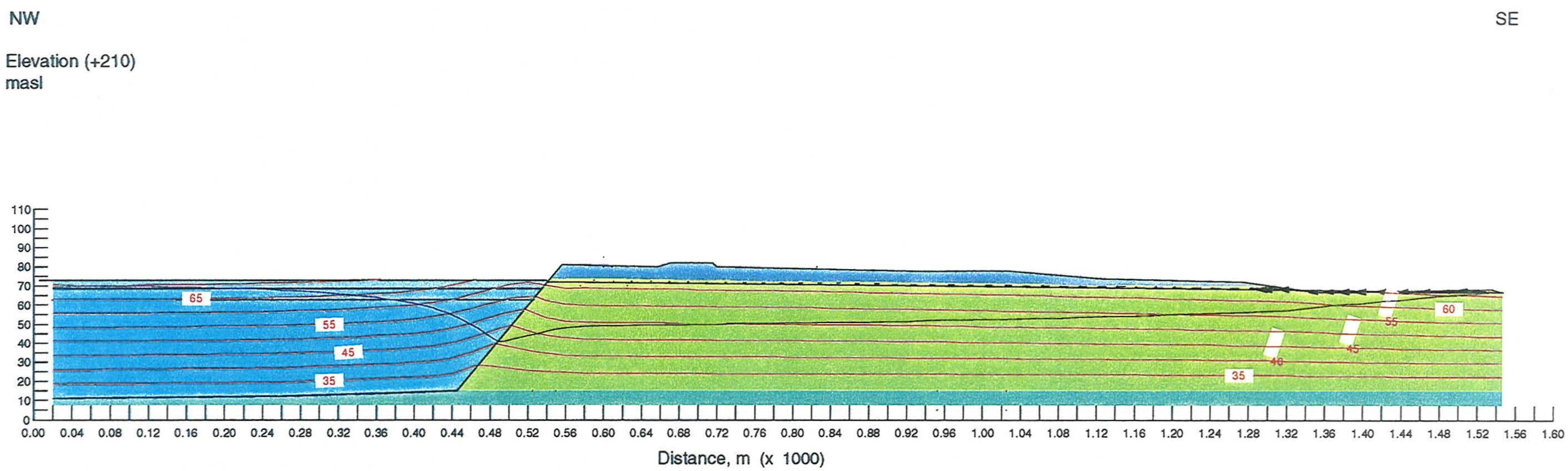
Geologic units and Geographic Features are labelled in Figure H3-33

Location of Cross Section 1-2 shown in Figure H3-6

Vertical Exaggeration 2x

Revised Figure IV-15

Simulation Model Results
Vertical Cross-Section 1-2
2010, Pit 1



NOTES

Contours are hydraulic head, (+210 m) asl

Groundwater surface

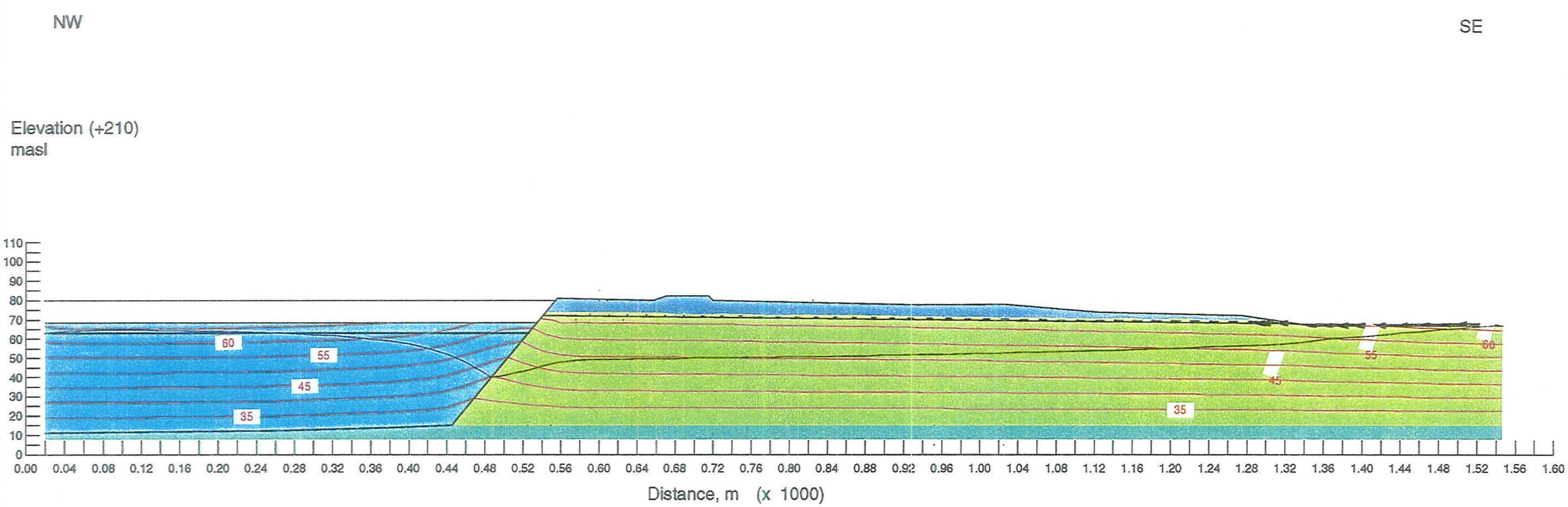
Geologic units and Geographic Features are labelled in Figure H3-38

Location of Cross Section 5-1 shown in Figure H3-6

Vertical Exaggeration 2x

Revised Figure IV-17

Simulation Model Results Vertical Cross-Section 5-1 2022, Pit 5



NOTES

Contours are hydraulic head, (+210 m) asl

Groundwater surface

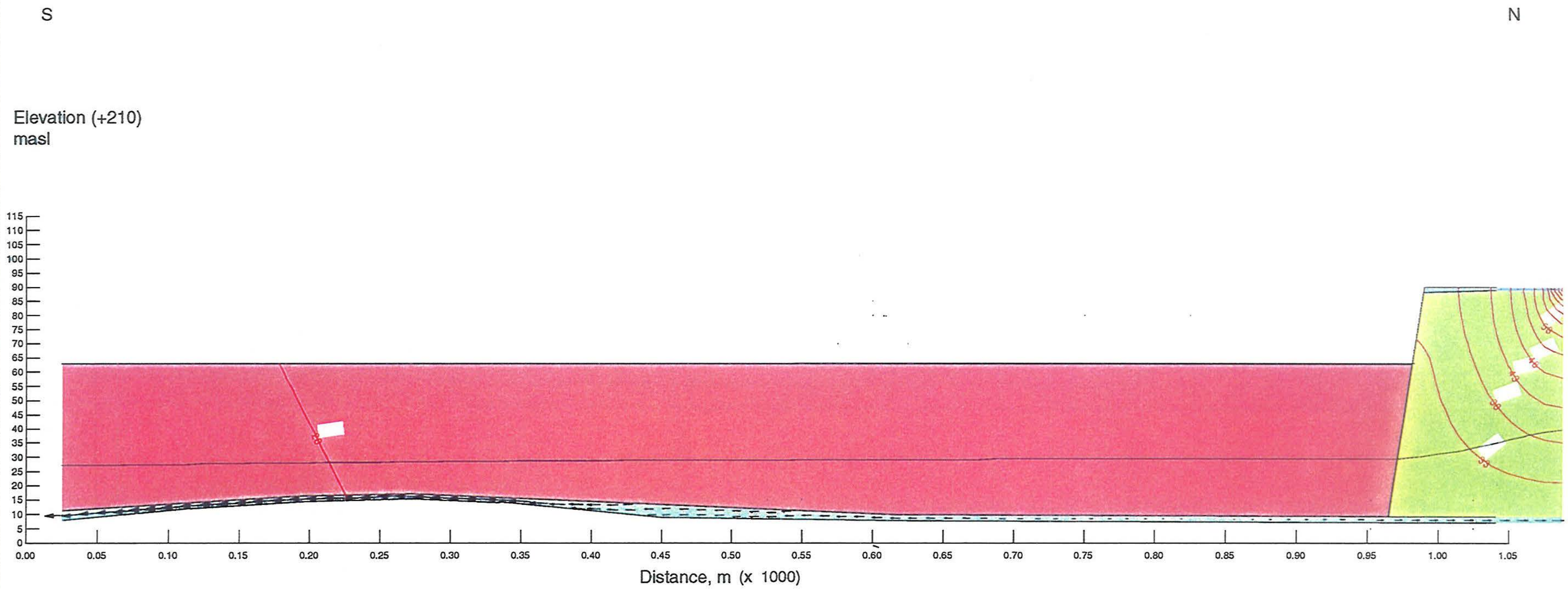
Geologic units and Geographic Features are labelled in Figure H3-38

Location of Cross Section 5-1 shown in Figure H3-6

Vertical Exaggeration 2x

Revised Figure IV-23

Simulation Model Results
Vertical Cross-Section 5-1
2025, Pit 5



NOTES

Contours are hydraulic head, (+210 m) asl

Groundwater surface

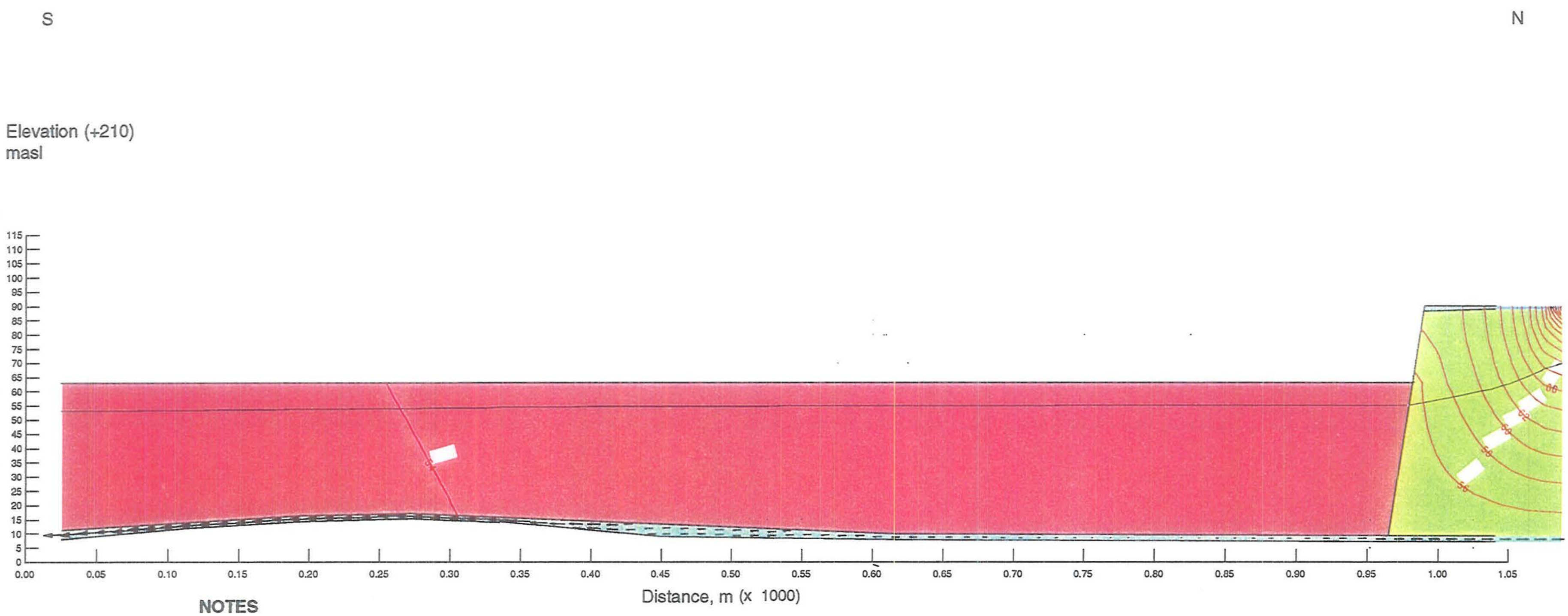
Geologic units and Geographic Features are labelled in Figure H3-40

Location of Cross Section 6-1 shown in Figure H3-6

Vertical Exaggeration 2x

Revised Figure IV-24

Simulation Model Results
Vertical Cross-Section 6-1
2025, Pit 6



NOTES

Contours are hydraulic head, (+210 m) asl

Groundwater surface

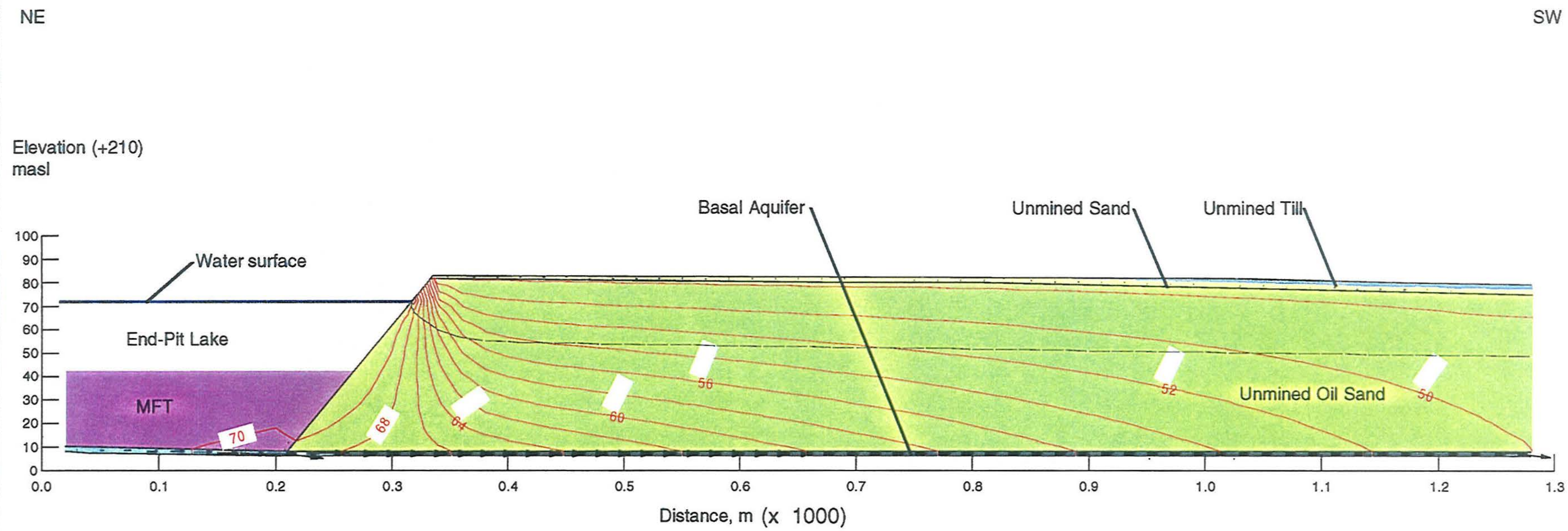
Geologic units and Geographic Features are labelled in Figure H3-40

Location of Cross Section 6-1 shown in Figure H3-6

Vertical Exaggeration 2x

Revised Figure IV-30

Simulation Model Results
Vertical Cross-Section 6-1
2030, Pit 6



NOTES

Contours are hydraulic head, (+210 m) asl

Groundwater surface

Location of Cross Section EPL shown in Figure H3-6

Vertical Exaggeration 2x

Revised Figure IV-42

Simulation Model Results
Vertical Cross-Section EPL
Far Future, End-Pit Lake

EUB No.	Exhibit No.
Information Requested By: AEP	
Date of I.R. June 12, 1998	

Question No. **1.1**

Shell No. **AEP 1**

Issue **Assessment Requirements**

Request

It is stated that "Degree of concern is an overall property associated with an impact and is a function of direction, magnitude, duration and geographic extent." *(Vol. III, p. E1-20.)* Please provide further clarification regarding the methodology and parameters for arriving at the degrees of concern referred to in the EIA, as in a number of instances, it is unclear how Shell arrived at the determination of degrees of concern.

Response

The degrees of concern concept was developed so that the reader would have one parameter to consider for each potential impact instead of several, such as magnitude and geographic scope. Degrees of concern are identified for residual effects, and assume that mitigation has been implemented. Thus, they were an attempt to make the findings of the EIA easier to interpret. Degrees of concern were developed systematically for every impact using Table E1-10. Degrees of concern should thus be regarded as a relative value that is most useful in comparing between impacts. The reader should always refer to the detailed impact ratings if more information on a particular impact is desired.

Question No. **2.1**

Shell No. **AEP 2**

Issue **Air Quality and Noise - Emissions**

Request

Clarify whether the design and construction of all storage tanks at the plant will meet the requirements prescribed in *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Aboveground Storage Tanks*, Canadian Council of Ministers of the Environment, Publication CCME-EPC-87E.

Response

The design and construction of all storage tanks will meet the requirements prescribed in *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Aboveground Storage Tanks*, Canadian Council of Ministers of the Environment Publication CCME-EPC-87E.

The current project basis assumes that floating roof tanks will be provided for storage of diluent and bitumen. Alternatively, a vapour recovery system that achieves equivalent results might be considered if there are advantages to integrating the vapour recovery with other plant vapour handling facilities.

Question No. 2.2

Shell No. AEP 3

Issue **Air Quality and Noise – Emissions**

Request A vapour recovery unit (VRU) is indicated for controlling emissions from the diluent storage tank (*Vol. III, p E 2-20*).

3.1 Does Shell presently have any details about the type of VRU that will be used (e.g. vapour recovery technology using condensation, adsorption or absorption; or a vapour destruction technology; or recycling of vapours) and whether a VRU would be dedicated to only this source (or would several sources be directed to a common VRU)?

Response 3.1 The details of the vapour recovery system have not been developed. The conceptual approach to vapour recovery will be better defined as part of feasibility front-end engineering to be completed in 1999.

A vapour recovery system will likely be installed that will recover vapours from more than one source, this will not be confirmed until detailed engineering is completed.

Request 3.2 If such details are presently not available, please indicate the appropriate timeframe when they would likely be established in the design process.

Response 3.2 Detailed engineering will begin in 1999 following the decision to proceed with the project.

Question No. 2.3

Shell No. AEP 4

Issue **Air Quality and Noise – Emissions**

Request Please clarify the type of system that will be used to minimize emissions from the diluted bitumen product tanks (e.g., will it be a floating roof system, a vapour control system where vapours will be collected and treated, or both). At certain points in Shell's submission, a floating roof system appears to be described (*Vol. I, Table 16-4*) and at other points a vapour control system is mentioned (*Vol. II, p. 2-60*). Please note that the norm at the existing oil sands processing plants has been to use a vapour control system for diluted bitumen storage, so a justification should be provided if a lesser control system is being proposed.

Response

The selected vapour control system to be used to minimize emissions from the diluted bitumen product tanks will depend on the vapour pressure within the tanks, which in turn is dependent on the nature of the contents and the temperature. Shell will review current practice and will follow the *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Aboveground Storage Tanks*, in designing the vapour management system for the diluted bitumen product tanks.

Question No. **2.4**

Shell No. **AEP 5**

Issue **Air Quality and Noise – Emissions**

Request

The expected solvent losses to the tailings are discussed in the application and are quantified in the mass balance tables in Figures 9-1 and 9-2 in the application (*Vol. I, p. 5-11*). To provide a context, please compare the expected rate (quantity) of solvent losses at the tailings settling pond to losses at tailings ponds at each of the existing two oil sands processing plants (Suncor and Syncrude), and discuss any differences.

Response

The solvent loss anticipated in the preliminary design of the tailings solvent recovery unit was 6.9 t/d or 11.25 m^3/1000 m^3 of bitumen production. This was based on a recovery of 88%, which was based on Shell's understanding of the performance of the existing commercial naphtha recovery unit at Syncrude.

The different solvent used, i.e., paraffinic versus naphtha, and the different characteristics of the tailings stream in Shell's proposed froth treatment and bitumen clean up schemes require that further test work be conducted to determine and optimize recovery performance.

Shell's understanding of current losses at Syncrude and Suncor is as follows:

- Syncrude: 5.7 m^3/1000 m^3 bitumen production (personal communication with Syncrude)
- Suncor: 6.12 m^3/1000 m^3 bitumen production (Figure D1-2 Millennium application)

It is Shell's intent, through testing and final commercial design, to reduce the solvent loss to tailings from that projected in the application.

Question No. 2.5

Shell No. AEP 6

Issue **Air Quality and Noise – Emissions**

Request

Will any redundancy be provided in the TSRU system (e.g. two units that could each handle the full flow). If redundancy is not provided, could circumstances arise where tailings may be directed to the tailings settling pond without solvent recovery (e.g. if the TSRU requires maintenance or repairs)?

What would be the expected frequency of such events, and what would the rate of solvent loss to the pond be during such time periods?

Response

The preliminary design is based on only one TSRU column. As it is expected that this unit will have a high service factor, no redundancy has been considered.

Preventative maintenance will be completed during plant turnarounds so that no additional losses would result. During forced outages, losses would increase by a factor of 10. Once reliable operation has been established, the forced outage rate during production is expected to be less than 1%.

A reliability analysis of the TSRU unit and its supporting components is required to determine the frequency and duration of outages. This reliability analysis will be carried out as part of the detailed design process.

Question No. 2.6

Shell No. AEP 7

Issue **Air Quality and Noise – Emissions**

Request

Based on the description of the TSRU, it appears that vapours from the TSRU vessel will be collected and recycled or reused (i.e. the vessel will not vent to atmosphere) (*Vol. I, p. 15-11*). Please confirm that the above understanding is correct.

Response

The TSRU vessel will not vent to the atmosphere.

Question No.	2.7
Shell No.	**AEP 8**
Issue	**Air Quality and Noise – Emissions**

Request

Has Shell considered whether the solvent that is recovered by the TSRU could pick up contaminants from the tailings stream? If the recovered solvent contains contaminants, could release of the contaminants to the atmosphere occur when the solvent is lost to the tailings settling pond? If so, please discuss how this situation would be managed to minimize emissions, and discuss the potential for any environmental or health effects resulting from such emissions.

Response

The solvent is a mixture of light paraffinic hydrocarbons and the operating conditions in the TSRU are such that the solvent is selectively removed from the tailings. The solvent will pick up trace amounts of heavier hydrocarbons from the bitumen, which will be recycled with the paraffin. Because of the wide separation of the paraffin from the initial boiling range of the bitumen, the concentrations will be low and will not have a detectable effect on process performance. Their presence in the solvent will not have any impact on the character of the tailings.

Question No.	**2.8**
Shell No.	**AEP 9**
Issue	**Air Quality and Noise – Emissions**

Request

Emission factors for the Muskeg River Project tailings settling pond appear to be derived on the basis of measurements that were conducted at the Syncrude Mildred Lake Settling Basin during 1992 (*Vol. III, p. E2-22*). It is AEP's understanding that both Suncor and Syncrude have recently done additional measurements of pond emissions, and that the predicted emissions may be higher than was previously expected.

Can Shell provide any more up-to-date information to predict what the emissions from the tailings settling pond may be? Please indicate whether any of the findings in the EIA report would likely change as a result of using more recent emission information.

Response

If more recent Syncrude emission factors are applied to the Muskeg River Mine tailings settling pond, the associated VOC emissions increase from 1.5 t/d to 7.4 t/d. However, comparison with observed ambient air quality at four locations in the area (e.g., Fort McMurray and Fort McKay) showed that dispersion modeling using the higher Syncrude emission factor overpredicted the maximum VOC ambient observations by a factor of 6 (see Section 7.4, Volatile Organic Compound Emissions, and Section 7.3, Ozone Formation, in the Project Update).

Question No. 2.9

Shell No. AEP 10

Issue Air Quality and Noise – Emissions

Request

This table does not include benzene (*Vol. III, p. E2-23)*. It is AEP's understanding that Suncor has measured benzene emissions from tailings ponds, and has included this substance in reports for the National Pollutant Release Inventory (NPRI). Please clarify whether benzene emissions are likely to occur from the Muskeg River Project tailings settling pond (or any other sources, such as mine surfaces), what the expected emission rates may be, and the expected nature and significance of any environmental effects.

Response

The updated Mildred Lake Settling Basin measurements indicate some benzene emissions. Extrapolating the Mildred Lake Settling Basin benzene emission factor to the Muskeg River Mine pond indicates a potential benzene emission of 0.027 t/d (27 kg/d).

Similarly, the updated Syncrude mine measurements indicate some benzene emissions. Extrapolation of the Syncrude mine factor to the Muskeg River Mine indicates a potential benzene emission of 0.0001 t/d (0.1 kg/d).

These emissions compare to benzene emission estimates of 0.0047 t/d (4.7 kg/d) from the mine fleet exhausts.

Question No. 2.10

Shell No. AEP 11

Issue Air Quality and Noise – Emissions

Request

11.1 The removal and rejection of asphaltenes is described in the application *(Vol. I, pp. 5-9 and 5-15*) and it is indicated that the froth treatment tailings stream will contain rejected asphaltenes (*Vol. I, p. 6-1*). Please clarify the quantity of asphaltenes that will be directed to the tailings settling pond

Response

11.1 The quantity of asphaltenes removed is estimated to be less than 0.3 wt% of the total tailings stream.

Request

11.2 Is the presence of these asphaltenes in the froth treatment tailings stream expected to affect air emissions from the tailings settling pond, or have any other environmental significance? Please describe the expected nature and significance of any associated environmental effects.

Response

11.2 The presence of asphaltenes will not affect air emissions, as they are present as solids. Asphaltenes are large, complex, heavy hydrocarbon molecules. Laboratory testing has confirmed that they do not contribute to aquatic toxicity.

Question No.	**2.11**
Shell No.	**AEP 12**
Issue	**Air Quality and Noise – Emissions**
Request	Shell indicates that, in the absence of process specific data, the Syncrude emission factors (based on 1992 data) provide a first order indication of both the type and magnitude of emissions that could occur from the Muskeg River Mine Project tailings settling pond. (*Vol. III, p. E2-22*). When and how might process specific data be obtained to improve the level of understanding of this subject? Could Shell's upcoming pilot plant work provide any useful information in this regard? If so, please describe the type of related information that the pilot plant work may provide, and when it is expected to be available.
Response	See the response to AEP 16 and Section 7.4 (Volatile Organic Compound Emissions) in the Project Update.

Question No.	**2.12**	
Shell No.	**AEP 13**	
Issue	**Air Quality and Noise – Emissions**	
Request	13.1	Clarify the proximity (i.e. distance) of the proposed tailings settling pond to Fort McKay.
Response	13.1	The southern edge of the MRM tailings settling pond is located about 4 km to the north of Fort McKay. For comparison, the northern edge of the Mildred Lake Settling Basin pond is located about 17 km from Fort McKay.
Request	13.2	Do any special mitigative actions need to be taken due to the proximity of the pond to Fort McKay? For example, will Shell be able to use the same types of audible bird deterrent devices that are used at other facilities, or could such activities cause a noise problem in Fort McKay?
Response	13.2	Shell recognizes that the close proximity of the tailings settling pond to Fort McKay will require prudent operation of the facility to minimize noise and odour. Shell is working closely with the community of Fort McKay to resolve issues related to the tailings settling pond. Noise and odour will be monitored during construction and operation, and appropriate mitigation implemented, if necessary.
Request	13.3	Are any special actions needed to reduce the potential for odours or other emissions from the pond that may pose an aesthetic or health concern?

Response 13.3 In general, odours from the tailings would result from upset events (e.g., the uncontrolled discharges of hot diluent to the pond). The prudent operation of the extraction process and the TSRU will minimize and reduce the occurrence, magnitude and duration of odours from the tailings pond discharge and the pond. See also the response to AEP 147.

Question No. **2.13**

Shell No. **AEP 14**

Issue **Air Quality and Noise – Emissions**

Request A primary extraction process schematic is provided in Figure 5-1 in the application (*Vol. I, p. 5-6*) and emissions are also briefly discussed (*Vol. III, p. E2-20*).

14.1 Please comment further on the type and magnitude of emissions that may occur from vents associated with major processing units (e.g. rotary breakers, agitation tanks, primary separation vessel, deaerators), and the basis for information that is provided.

Response 14.1 The extraction process will operate at about 50°C. Therefore, any emissions of hydrocarbons will be directionally reduced from current operations. As emissions from current extraction operations are not significant, the emissions from the Muskeg River Mine extraction facilities will not be significant.

The rotary breaker is a rotating screen and lump breaker into which oil sands and hot water are added. The screen is enclosed with a hood to limit the amount of water vapour escaping to atmosphere. At the targeted operating temperature, minimal, if any, hydrocarbon vapours will be emitted. The agitation tanks operate at temperatures in the range of 45-50°C. At these temperatures, minimal, if any, hydrocarbon emissions are expected. The design and operating conditions of the rotary breaker and agitation tanks are expected to be similar to those approved for use at the Suncor Steepbank mine. Shell has access to future operating data related to rotary breakers and agitation tanks installed at the Steepbank operation from which to base detailed engineering.

The primary separation vessels will operate in a temperature range of 45-50°C. Their design will be similar to the deep-cone vessels used at Syncrude.

Request 14.2 Has Shell considered mitigative actions to minimize emissions from any of these sources?

Response 14.2 The preliminary design of the deaerator has a target temperature of 65°C (compared to current operations of 80 to 85°C) and a partial vacuum. The system will be enclosed and contains a condenser to remove water vapor. At the targeted operating temperature, minimal, if any, hydrocarbon vapours are anticipated. If hydrocarbon vapours are present with the water vapour, they will be condensed along with the condensed water and combined with the extraction tailings stream.

Question No. 2.14

Shell No. AEP 15

Issue **Air Quality and Noise – Emissions**

Request

The bitumen froth treatment process is described in the application (*Vol. I, p. 5-5*). Please clarify whether any processing units will vent to atmosphere after solvent is added to the process, or whether only enclosed or blanketed units (with vapour collection) will be used after the addition of solvent.

Response

All units containing solvent will be enclosed or blanketed.

Question No. 2.15

Shell No. AEP 16

Issue **Air Quality and Noise – Emissions**

Request

In the application, Shell's planned 20 t/h pilot extraction facility is briefly discussed (*Vol. I, p. 5-13*). Please discuss Shell's plans for any monitoring of emission sources, such as process vents, during the pilot facility studies.

Response

Measurements to characterize and quantify point and fugitive sources of VOC and TRS emissions will be conducted during the pilot testing program scheduled to start in late June. Shell plans to submit an annual air emissions summary and evaluation report in the first quarter of 1999.

The froth treatment diluted bitumen product will go through a solvent recovery unit (SRU). The tailings will go through a separate tailings solvent recovery unit (TSRU). One of the key objectives of pilot operations is to test the efficiency of both the SRU and TSRU. As solvent recovery is both economically and environmentally driven, it must be maximized.

Shell is scoping an air emissions measurement program for the pilot plant that will realize the intermittent and changing conditions of the test runs, and target the representative and steady-state run that would be useful for developing the program for the commercial plant.

Question No. 2.16

Shell No. AEP 17

Issue **Air Quality and Noise – Emissions**

Request

Please clarify whether some mine shovels will be powered by diesel engines and others by electric power. At a few points in the application, electric shovels are mentioned (*Vol. I, pp. 4-18 and 4-41, Table 4-4*), whereas diesel fuel is mentioned at other points (*Vol. III, p. E2-6*). Briefly discuss the reasons for selecting each type of shovel, and the environmental significance from an air emissions standpoint.

Response

The selection of mining shovels is based on the efficient operation of the mine and extraction plant, which requires a combination of electric and diesel powered shovels. Diesel-hydraulic shovels provide the mining operation with significantly more selectivity than electric cable shovels in areas such as geological ore-waste contacts, thus helping to minimize dilution. Electric cable shovels are less maneuverable and selective with their digging operation, but provide a high degree of productivity where selectivity is not as critical. The environmental performance of the shovel fleet cannot be evaluated in isolation, but as an integral part of the overall environmental performance of the whole mining and extraction plant operation. If some diesel-hydraulic shovels are not used, mining dilution would cause the plant to be inefficient.

Diesel powered shovels result in emissions of combustion products that include NO_x, CO, VOC and PAH in the mine pits. These emissions will be dependent on the fuel consumption according to the emission factors given in the EIA, Volume 3, Table E2-2. Electric powered shovels will reduce emissions from the mines. However, as electricity in Alberta is primarily derived from coal combustion, the use of electrically powered shovels will result in the associated products of combustion being vented to the atmosphere at the source of the electrical generators. Combustion products from coal fired generating units include SO_2, NO_x, CO, PAH and metals.

Question No. 2.17

Shell No. AEP 18

Issue **Air Quality and Noise – Emissions**

Request

The application indicates that mine fleet vehicles with effective emission control technology will be selected *(Vol. I, p. 16-18, Table 16-4).*

Does Shell have a specific control technology in mind when the term "mine fleet vehicles equipped with emission control technology" is used in the submission *(e.g. Vol. III, p. E2-60)*? Confirm whether it is Shell's intent to determine the availability of diesel engine designs and other types of engines with reduced air emissions, and to incorporate criteria for reduced air emissions into the selection process for new equipment, and into engine replacement and rebuilding procedures for existing equipment during mine operations.

Response Shell does not have a specific control technology in mind for the mine fleet vehicles. The use of the largest available haul trucks will improve operations efficiencies and, hence, reduce emissions. Engine manufacturers have improved the efficiency of their trucks over the past years. There is a limited number of large mine equipment manufacturers. However, Shell will discuss this issue with equipment manufacturers.

Question No. **2.18**

Shell No. **AEP 19**

Issue **Air Quality and Noise – Emissions**

Request 19.1 Shell has stated that several potential diesel supply sources are being considered *(Vol. I, p. 7-11).* Will emissions associated with diesel fuel use be a consideration when Shell selects/specifies a diesel supply?

Response 19.1 The diesel emission factors are based on the manufacturer's use of a generic diesel fuel. Emission factors are not available for differing diesel blends.

Request 19.2 Would a significant change occur to the diesel emission factors estimates which are presented in the EIA report (*Vol. III, p. E2-12, Table E2-2*) if the diesel were to be obtained from one of the existing two oil sands processing plants in the Fort McMurray region?

Response 19.2 Diesel quality, price and transportation requirements will be factors considered in selecting diesel supply. Shell does not expect any significant changes to the emission factor estimates provided, if diesel were to be sourced from either Syncrude or Suncor.

Question No. **2.19**

Shell No. **AEP 20**

Issue **Air Quality and Noise – Emissions**

Request Shell has indicated that source monitoring will be done to confirm VOC emissions from the mine fleet (*Vol. III, p. E2-55*). Are any details presently available about the specific VOC monitoring that will be conducted? Will monitoring of emissions from mobile mine equipment also include PAH products from incomplete combustion? Does either Shell or BHP presently have experience in implementing a program to monitor and minimize emissions from mine mobile sources?

Response Confirmation of mine fleet emissions will be undertaken through the use of available data from the manufacturer. It is not Shell's intent to set up and operate a mobile vehicle emission testing facility. However, Shell will ensure that the fleet is kept in good running order, which will include maintenance of any pollution reduction features that might be incorporated.

Question No. 2.20

Shell No. AEP 21

Issue **Air Quality and Noise – Emissions**

Request EUB ID 94-4 requires a noise impact assessment. With respect to Key Question HH-6 *(Vol. III, p. E12-55)*, what is the expected Muskeg River Mine impact on Fort McKay night-time sound levels? Please explain how the impacts were assessed. Describe any noise monitoring and mitigation alternatives that will be put into place to pro-actively manage potential impacts on nearby residential sites (e.g., Fort McKay).

Response The noise assessment for the Muskeg River Mine Project was conducted based on the results of the noise measurements and modeling completed for the Aurora Mine EIA. For the Aurora EIA, noise levels measured at various distances from truck-and-shovel operations at Syncrude's Mildred Lake North Mine were used as surrogates for potential noise levels at the Aurora Mine. Sound levels that could occur at Fort McKay, as a result of the Muskeg River Mine Project and the Aurora North Mine, were predicted.

The assessment indicated that permissible day and night sound levels in Fort McKay might be exceeded on occasion. The noise assessment was preliminary and did not consider natural and artificial buffers, such as trees and dykes, which will exist between the mine and the community of Fort McKay. Shell is committed to:

- monitoring noise during the operation phases of the project
- meeting regulatory noise guidelines, by implementing mitigation measures where necessary

Shell is completing a more detailed noise impact assessment, according to EUB ID 94-4, and will be providing this information to AEP and the EUB by the end of July.

Question No. 2.21

Shell No. AEP 22

Issue **Air Quality and Noise – Proposed Bitumen Extraction Process**

Request Based on the information that is provided in the application, it appears that Shell is not proposing a low temperature extraction process, as it believes that the current technical risk of a low temperature process is unacceptable *(Vol. I, p. 5-25)*. Please confirm whether the above is correct, and specifically describe why Shell finds the Low Energy Extraction Process, which was recently proposed by Syncrude Canada Ltd. for the Aurora Mine Project, to be unacceptable for the Muskeg River Project.

Response

Shell is proposing an extraction scheme that uses process temperatures in the range of 45-50°C that are significantly lower than the conventional Clark hot water process. The Clark hot water process as practised in commercial operations, operates at temperatures in the range of 70 to 80°C. In this respect, Shell is proposing a low temperature extraction process.

When Shell selected its process scheme and the process parameters at which the scheme would operate, field and research piloting of lower temperature processes (less than 35°C) were not complete. Shell has subsequently entered into an agreement with Syncrude to access research and pilot data on its low energy extraction (LEE) process for evaluation purposes. Shell has the option to license this technology from Syncrude and aspects of the technology from the Alberta Government.

The application of lower temperature bitumen extraction processes, such as the LEE process, has only reached the field pilot stage. No commercial operations are in place that operate at process temperatures lower than 50°C. For this reason, Shell believes there is technical risk, particularly for a grassroots project.

Shell is continuing to evaluate extraction process temperatures lower than 50°C for its potential benefit on process economics and energy intensity of the process.

Question No. **2.22**

Shell No. **AEP 23**

Issue **Air Quality and Noise – Proposed Bitumen Extraction Process**

Request

Shell has indicated that it will continue to consider lower extraction process temperatures *(Vol. I, p. 5-25)*. Please indicate the difference in CO_2 emission rates (e.g. in t/d) that would occur if a low temperature extraction process (e.g. 25°C) were to be used rather than the warm water process (45° to 50°C) that Shell is currently proposing.

Response

The warm water extraction process currently proposed by Shell uses less energy than the Clark hot water processes currently being used by oil sands operators. In addition, the Shell process does not use chemicals (caustic) to aid in the extraction of the bitumen. A comparison of CO_2 emissions associated with the hot water processes currently used, the Shell proposed warm water process, and the low temperature process recently proposed in other oil sands applications is shown in Table 23-1. These figures are approximate, because the amounts can vary depending on the degree of process heat integration, summer and winter cases, and final technology arrangement.

Table 23-1: Comparison of CO_2 Produced in Extraction Processes

Technology	Temperature	t/d of CO_2 produced (based on a 150,000 bbl/d bitumen production facility)
Clark hot water	80°C	3,658
Shell warm water (winter case)	45 - 50°C	3,049
Low temperature (winter case - Aurora Trains 1 and 2)	25°C	2,500

Question No. **2.23**

Shell No. **AEP 24**

Issue **Air Quality and Noise – Proposed Bitumen Extraction Process**

Request

Shell appears to indicate that a non-caustic extraction process is being proposed for this Project due to the impact of caustic on the behaviour of tailings settling and bioremediation of tailings water *(Vol. I, p. 5-16)*.

24.1 Please provide some additional details about these expected environmental benefits and the level of understanding of the impact of caustic on these environmental factors.

Response

24.1 Tailings waters from the non caustic process contain lower levels of naphthenic acids and overall lower aquatic toxicity than tailings waters from the caustic process. This should reduce the time required for bioremediation of the water. In addition, because of the non-dispersed nature of the clays in the fine tailings, the recycle water has faster settling characteristics. Therefore, the potential settling area of the pond can be made smaller. This results in lower total dissolved solids in the CT release water.

Request

24.2 Also, clarify whether the addition of caustic could allow a reduction in the extraction process temperature, and whether Shell is of the opinion that the overall environmental benefits of a non-caustic process at this time outweigh the environmental benefits of a lower temperature process with caustic.

Response

24.2 The addition of caustic would not necessarily allow reduction in the extraction process temperature. As the temperature of the process is reduced below say, 35°C, the viscosity of the bitumen is sufficiently reduced that caustic becomes less effective, and other types of process aids are required. For example, the Syncrude LEE process as described in the application for the Aurora Project, proposes the use of process aids other than caustic to improve bitumen flotation.

Shell believes there are environmental benefits to be gained from reducing process temperatures and from the elimination of caustic. It is difficult to make comparisons because of the dissimilarity of the impacts involved.

Question No.	**2.24**
Shell No.	**AEP 25**
Issue	**Greenhouse Gas Measurement**

Request

Shell has stated that it participates in the Voluntary Climate Challenge and Registry Program (*Vol. III, p. E2-58*). Please discuss Shell's overall greenhouse gas management plans and comment on the effect of the Muskeg River Project on Shell's greenhouse gas management plans.

Response

Shell's commitment with respect to the Voluntary Climate Challenge and Registry Program has been to achieve stabilization of Shell's CO_2 and total greenhouse gas emissions at 1990 levels by the year 2000 based on the 1994 level of business activity. This has led to continuous improvement in the energy efficiency of Shell's oil and gas production facilities as well as improvements in energy efficiency in the refining and manufacture of oil products.

Shell believes that the oil sands will provide Canada with a secure source of affordable energy supply for the next 20 to 30 years, in the face of declining conventional reserves. Athabasca oil sands are competing with imported crudes in the North American market. The CO_2 associated with the production of 150,000 bbl/day of synthetic crude from the Athabasca oil sands is less than the CO_2 produced from the partial upgrading and transportation of Venezuelan crude to North America, which is the fastest growing alternative.

The Muskeg River Mine Project will increase the overall greenhouse gas emissions for Shell as a result of the increase in Shell's production. Shell is committed to continuously improving the energy intensity of the proposed bitumen production facility and the proposed Scotford Upgrader facility in an effort to reduce greenhouse gas emissions. Targets will be set for these facilities and incorporated into Shell's commitment to the Voluntary Challenge Program (see Appendix B). In addition, the Shell oil sands facilities will be compared with imported crudes on a full cycle basis to ensure that the CO_2 associated with the production, shipping, and refining of oil sands products is competitive with imported crudes.

Question No.	**2.25**
Shell No.	**AEP 26**
Issue	**Air Quality and Noise – Mine Clearing/Slash Burning Emissions**

Request

Shell has described some mitigative measures that will be implemented to reduce emissions from the burning of waste material (slash) from site vegetation clearing *(Vol. III, p. E2-8)*. Shell further indicates that it will participate with other industries in the region to examine means to dispose of slash other than by burning. Please summarize any ongoing initiatives by industries in the region to examine this issue, and describe any further actions that Shell is considering.

Response

The oil sand operators and members of OSEC and AEP met in January to discuss alternatives to disposal of slash. No resolution on alternatives to burning of slash has been reached. This group is to meet again in late 1998. As the mining operation develops, Shell will investigate any opportunities for enhanced use of slash where applicable and economic. See also the response to OSEC 30.

Question No. 2.26

Shell No. AEP 27

Issue **Air Quality and Noise – Particulates**

Request Please discuss whether any changes to particulate deposition patterns (e.g., deposition of airborne particulates that occurs from sources such as wind-entrained dust from exposed soil surfaces) are expected to occur as a result of the Muskeg River Project.

Response Under dry, windy conditions, fugitive haul trucks can generate particulate emissions from tire-road surface interactions. Also under dry windy conditions, wind blown dust from the tailings pond, sand storage and overburden storage can occur. Ambient concentrations and associated deposition are expected to be maximum at the point of emission and to decrease with increasing distance. These emissions are controllable through progressive revegetation and road dewatering. Therefore, the resulting ambient concentrations and deposition were not rigorously calculated.

Question No. 2.27

Shell No. AEP 28

Issue **Air Quality and Noise – Ambient Air Quality**

Request An ambient air monitoring trailer in the vicinity of the mine is mentioned in the application *(Vol. I, pp. 10-9 and 16-25)*. Is Shell proposing to install and operate a trailer, or is Shell anticipating that this would be done by the Southern Wood Buffalo Zone Airshed Monitoring Program? When is this monitoring likely to commence, and how will the collected data be used by Shell?

Response At this stage, Shell has not identified the specific mechanism for setting up or operating the trailer. Given the proximity of the Aurora North Mine and Muskeg River Mine projects, a single trailer to serve both Syncrude and Shell needs might be desirable. The challenge will be to select a location that can be regarded as permanent, appropriately located with respect to current and future sources and will have power and access. The collection of data would ideally include background data, to be collected before the operation of the Muskeg River Mine. See also the response to AEP 35.

Question No. 2.28

Shell No. AEP 29

Issue **Air Quality and Noise – Ambient Air Quality**

Request Please clarify whether Shell believes that the existing ambient air quality trailer in Fort McKay measures sufficient parameters to establish baseline conditions with which to compare future conditions (e.g., after the Muskeg River Project is operational).

Response The upgraded Fort McKay trailer comprises continuous, intermittent and passive monitoring. The station is designed to collect data to meet human health and ecological needs. Therefore, Shell believes that the upgraded station measures sufficient parameters to establish baseline and future conditions.

Question No. 2.29

Shell No. AEP 30

Issue **Air Quality and Noise – Ambient Air Quality**

Request Shell has stated that it proposes to participate in an industry initiative (with Syncrude and Suncor) to undertake more refined photochemical modeling, using more recent VOC data and a more up-to-date model, to predict the potential for photochemical ozone production *(Vol. IV, p. F2-16)*. Please provide an update on the status of these studies, discuss intentions and timelines regarding any future studies and, if available, submit the results of the more refined modeling.

Response See Section 7.3 (Ozone Formation) in the Project Update. See also the response to AEP 35.

Question No. 2.30

Shell No. AEP 31

Issue **Air Quality and Noise – Ambient Air Quality**

Request Shell states monitoring of air emissions (NO_X) will be done as part of the Southern Wood Buffalo Air Shed Monitoring Program *(Vol. I, p. 10-17)*. What mitigation does Shell propose if air emissions are found to have a negative impact on soil and vegetation immediately around the plant site?

Response Based on the monitoring program undertaken by Syncrude adjacent to their North Mine, it is not clear that air emissions will have an adverse effect. Maximum NO_2 concentrations were less than the ambient air quality objective. The area immediately around the mine and plant is a restricted area site and ambient concentrations will have to be regarded in this light. Shell will design and implement a detailed monitoring program through an internal monitoring committee (see the response to AEP 35).

Question No. 2.31

Shell No. AEP 32

Issue **Air Quality and Noise – Acidifying Emissions**

Request

Predictions of acidic deposition using the CALPUFF model are presented in the EIA report, and a description of the CALPUFF model has been presented *(Vol. II, Appendix II)*.

32.1 Please comment on the level of conservativeness that is expected in the predicted potential acidifying input (PAI) values that are presented in the EIA report *(Vol. II, p. D2-49)*, and identify any potential short comings of the model or constraints on findings.

Response

32.1 All models have shortcomings when compared to the real world processes they are attempting to simulate. The CALPUFF strengths include the use of a PUFF algorithm that allows plumes to follow hour-by-hour wind changes and the incorporation of SO_x and NO_x chemistry and deposition process. Previous models that have been applied in Alberta (e.g., SULDEP and ADEPT) do not have these strengths.

Notwithstanding the strengths, the shortcomings include the replication of the initial dispersion associated with mine pit emissions and the associated calculation of deposition adjacent to the mine pit. Shell made modifications to the pit input parameters to result in predictions of ambient concentrations that were expected on the basis of observations at the Syncrude North Mine. Deposition calculations assumed a uniform canopy type (i.e., forest) up to the edge of the pit. As the area adjacent to the edge of the pit will be cleared, the assumption of a forest canopy will result in an overestimate to the deposition. Shell also assumed summer-type deposition to occur all year round. This will be conservative as the Leaf Area Index (LAI) will be lower during the winter. Shell selected what they believed to be realistic parameters with an element of conservatism. As with the previous deposition models (e.g., ADEPT), it is difficult define the level of conservativeness for the predictions.

Request

32.2 Also, provide further details on how the model was run, with emphasis on the major optional and default features of the model *(Vol. II, p. II-8, Appendix II)* that may influence the results, or where uncertainties may exist. Include in these details a discussion of the model receptor spacing, and how this grid may affect the model output.

Response

32.2 Parameters adopted for the application of the CALPUFF model include:

- 14,568 h (607 d) of meteorological data beginning November 1, 1993, from the 75 m level of the Mannix tower. Wind speed power law coefficients of 0.21, 0.21, 0.23, 0.4, 0.62 and 0.5 were assumed for PG classes A through F.

- RSA grid origin (0 km, 0 km) at the Suncor FGD stack. Southwest corner (-70 km E and -80 km N). Northeast corner (70 km N and 80 km N). Grid spacing of 4 km resulted in 1,527 receptor locations. A grid resolution of 4 km means that we cannot resolve concentration or deposition characteristics that are less than this distance. Earth Tech, the developer of the model, confirmed that a 4 km spacing was appropriate.

- Chemical species included SO_2, SO_4^{2-}, NO_x, HNO_3 and NO_3^-. Wet and dry deposition for all these compounds were calculated and summed to arrive at a PAI. For particles, Shell assumed a geometric mass mean diameter of 0.48 μm with a geometric standard deviation of 2 μm.

- A high leaf area index of 7 was assumed to be applicable to winter and summer periods. Subsequent analysis has suggested an LAI of 6 for the foliage season, and an LAI of 4.3 for the non-foliage season might be more appropriate.

- Plume elements were modeled as puffs not slugs. The ISC-based PG plume spread coefficients were used.

Mines were modeled as volume sources.

Question No. **2.32**

Shell No. **AEP 33**

Issue **Air Quality and Noise – Acidifying Emissions**

Request

The EIA report acknowledges that questions remain about spring runoff impact of acidification on water quality (e.g., spring pH depression in sensitive waterbodies). Shell has stated that it will co-operate with other operators in the region to more fully understand acid deposition (*Vol. II, p. A-20*). Please provide clarification of the following:

33.1 Given the current knowledge of the environmental conditions in the fall that are conducive to generation of a spring acid pulse (e.g., cold temperatures preceding snow cover), is an estimation of the frequency and magnitude of spring pH depressions of sufficient severity to affect aquatic organisms possible from the climatological record? Has Shell evaluated the region's climatological record to determine if the parameters needed for this assessment (e.g. depth of frozen ground prior to snowfall, ground temperature, snowpack depths) are presently collected and, if such monitoring is lacking, would Shell consider undertaking the collection of these parameters?

Response

33.1 Spring acid pulses is a regional issue that should be addressed by the appropriate regional monitoring organization. Currently, the Acid Pulse Monitoring Program is being conducted under the Terrestrial Environmental Effects Monitoring (TEEM) Committee of the Wood Buffalo Environmental Association and through field programs conducted by AEP. Spring runoff and pH change studies were conducted on the Firebag and Steepbank rivers in 1990, 1996 and 1998, and on the Muskeg River in 1990. The Muskeg River showed no pH depression in 1990. The Muskeg is more basic, with a higher pH than the Steepbank and Firebag rivers. Continuation of this program through AEP or TEEM is expected.

Shell has not evaluated the region's climatological record to determine whether there are adequate data to perform this analysis. However, since July 1997, Shell has been participating as an observer on WBEA. Once Shell becomes a full member on TEEM, it will participate with the other operators in setting the scope and design of the effects monitoring and research programs. See also the response to AEP 35.

Request 33.2 With regards to spring pH depression in sensitive waterbodies, is there a sufficient basis for rating the "magnitude" as "low", the "frequency" as "medium", and the "degree of concern" as "low" in Table F5-12 (*Vol. IV, p. F5-18*) and in Table G5-10 (*Vol. IV, p. G5-14*)? It is noted that in Table E5-10 (*Vol. III, p. E5-43*) for spring pH depression in the Muskeg River, the "magnitude" is "undetermined", and the "degree of concern" is also "undetermined". Should a similar rating, or perhaps higher "degree of concern", be used for this issue in Table F5-12 and Table G5-10?

Response 33.2 Shell concurs with the reviewers. The rating of magnitude and degree of concern for spring pH depression should have been as follows in EIA, Volume 3, Section E5, and Volume 4, Sections F5 and G5:

- magnitude: undetermined
- degree of concern: undetermined

An acid pulse monitoring program is being conducted (see the response to AEP 33.1).

Question No. **2.33**

Shell No. **AEP 34**

Issue **Air Quality and Noise – Acidifying Emissions**

Request Moderate to High impact in the local area was identified related to the deposition of acid forming compounds that exceed the interim critical load (*Vol. III, p. E2-51*). What will be the impacts of increased acidification on vegetation, and consequently, terrestrial and aquatic ecosystems? Include potential impact to non-vascular plants such as lichens, which are a valuable food resource for woodland caribou, an endangered species in Alberta.

Response Moderate to high impacts were predicted in the EIA, Volume 3, Section E2, Air Quality, based solely on PAI values exceeding the interim critical loads. In Volume 3, Section E5, Water Quality, the potential for effects of acid deposition on aquatic life was evaluated in light of the buffering capacity of lakes in the region. As described in the EIA, aquatic impacts are unlikely from Shell's emissions. However, because of lack of information and predictive ability at the present, spring pH depression in susceptible streams from cumulative emissions from future oil sands operations cannot be ruled out. This issue is being investigated through TEEM of the WBEA and AEP (see the response to AEP 33).

The impacts of increased acidification on vegetation and wetlands is discussed in EIA, Volume 3, Section E9.8. Shell will participate in regional monitoring programs to determine impacts on vegetation from acidification. Shell is currently an observer in the meetings of the WBEA (formerly RAQCC) and will become a full member once the Muskeg River Mine is in operation.

Question No. **2.34**

Shell No. **AEP 35**

Issue **Air Quality and Noise – Air Related Monitoring Activities**

Request

Shell has stated a willingness to undertake air quality monitoring, however, it is not clear which monitoring activities will be undertaken independently, and which will be done collaboratively as part of multi-stakeholder regional air quality and acid deposition monitoring programs. In the EIA report, Shell has identified some uncertainties related to air quality. Please clarify Shell's intent to conduct air quality and deposition monitoring, and indicate how each program will address the uncertainties identified in the EIA report. Specifically:

a. List and discuss all air quality monitoring activities and initiatives that Shell is proposing to conduct independently of other stakeholder monitoring activities.

b. List and discuss all air quality monitoring activities that Shell is proposing to conduct collaboratively with other stakeholders. Include in this discussion the role that Shell anticipates taking in each of the programs being developed and implemented by the Regional Air Quality Coordinating Committee (RAQCC) (WBEA) and it's subcommittees. Discuss any changes or additions to the RAQCC (WBEA) programs that Shell may require in order to monitor air quality changes that arise from the Muskeg River Project activities, and how Shell will initiate and work with stakeholders to implement these changes. Please clarify how Shell will integrate peat *(Vol. I, p. E10-16)* and wetland vegetation *(Vol. I, p. A-27)* monitoring into the RAQCC (WBEA) Terrestrial Environmental Effects Monitoring program, as monitoring in these systems does not appear to be within the regional monitoring plans at this time.

Response

Conceptual monitoring programs have been identified throughout the EIA, the Project Update and in the questions and answers for various stakeholders. Once the approval for the Muskeg River Mine Project has been received, Shell will form an internal monitoring committee that will plan, design and implement the detailed monitoring programs for air, groundwater, surface water and wetlands, aquatic resources, reclamation (e.g., for terrestrial and aquatic ecosystems), biodiversity, wildlife resources and wildlife and human health. In the planning phase, this committee will consult with key stakeholders and will consider the current regional monitoring programs, such as the Regional Aquatic Monitoring Program (RAMP), hydrology and climate, the Wood Buffalo Environmental Association (e.g., Terrestrial Environmental Effects Monitoring), and complement these programs with project-specific requirements for the Muskeg River Mine Project. An example of a more detailed monitoring program designed for the Muskeg River Mine Project is provided for groundwater in the response to DFO 45. Shell will also continue to participate in the regional monitoring programs to design programs to address issues of increasing concern, such as the inclusion of ambient and environmental effects monitoring for NO_x under WBEA.

Shell intends to conduct air quality monitoring for the Muskeg River Mine Project, as follows:

- air quality monitoring initiatives, independent of other stakeholders, that includes:
    - an air quality trailer in the vicinity of the Muskeg River Mine that would be instrumental for NO_x, NO_2, NMHC and PM
    - NO_x concentrations from the vehicles in the mine
    - monitoring fugitive emissions from the facilities, as well as the reclaimed landscape
- participating in regional monitoring operated by the WBEA

Question No. **3.1**

Shell No. **AEP 36**

Issue **Geology, Terrain and Soils**

Request Bedrock in the Local Study Area (LSA) has inter-bedding of Clearwater Formation shales *(Vol. I, p. 2-7)*. Shell states that this formation is limited and restricted to the southeastern corner of Lease 13. Please outline how Shell will deal with disposal of these materials if found in the Project Area.

Response There is no evidence to suggest that Shell will find Clearwater Formation shales in the mining areas. In the unlikely event that these materials are found, they will be appropriately disposed of in the overburden disposal areas or mined-out pits.

Question No. **3.2**

Shell No. **AEP 37**

Issue **Geology, Terrain and Soils**

Request Shell states that "preference is for direct placement of the salvaged material on newly reclaimed surfaces". If this is not feasible, it will be either stored in designated stockpile areas for future reclamation applications, or discarded" *(Vol. III, p. E8-7)*? Discuss opportunities to make excess organic soils available to the public or industry.

Response Shell does not intend to create stockpiles of excess organic soils. The aim is to create a balance of soils recovered and soils used for reclamation.

Question No. 3.3

Shell No. AEP 38

Issue Geology, Terrain and Soils

Request 38.1 The Reclamation Soils Land Capability Class section of this table indicates no Class 2 soils will be replaced in the reclaimed landscape *(Vol. III, p. E8-17, Table E8-4)*. However, Figure 3 (in the *Terrain and Soil Baseline Report*) and Table E8-11 in Vol. III indicates 417.5 ha of Class 2 land as being disturbed by the Project Area, with 295 ha being returned in the end land use. Please clarify Shell's intention with respect to restoration of equivalent land use.

Response 38.1 Table E8-11 is confusing as it identifies both the disturbed and undisturbed soils in Lease 13. We realize a more appropriate table would have identified only those soils to be disturbed and then reclaimed as a result of the Muskeg River Mine. Within the disturbed area: 122.5 ha of Class 2, 117.5 ha of Class 3, 1,820 ha of Class 4 and 1,994 ha of Class 5 soils will be affected. Through reclamation: 3,052 ha of Class 3, 529 ha of Class 4 and 193 ha of Class 5 soils will be replaced. Although 122.5 ha of Class 2 soil will not be replaced through reclamation, substantially more hectares of Class 3 soils will be replaced than will be removed. Overall, the capabilities of the replaced soils are projected to be higher than for those removed.

Request 38.2 Please provide a capability class rating for each of the remaining areas of the plant site and pipeline right of way.

Response 38.2 The entire plant site will be reclaimed to Land Capability Class 3. The pipeline right-of-way will be reclaimed to its pre-construction capabilities (as shown in EIA, Volume 3, Part 1, Section E8 and the *Terrain and Soil Baseline Report*).

Question No. 3.4

Shell No. AEP 39

Issue Geology, Terrain and Soils

Request Table E8-4 indicates the plant site will most likely be covered with reclamation soil mix *(Vol. III, p. E8-17)*. The footnote to this table indicates that it is not known what type of reclamation soil will be applied to the plant site *(Vol. III, p. E8-23, Table E9-9)*.

As there is a surplus of reclamation materials in the Project area, clarify why Shell is unsure of how they intend to reclaim this area. Provide a reclamation plan showing land capability for the plant site

Response See the response to AEP 38.

Question No. 3.5

Shell No. AEP 40

Issue Geology, Terrain and Soils

Request 40.1 Please provide mine design information that will demonstrate the amount of area where direct placement of topsoil, and coarse woody debris could be used for reclamation.

Response 40.1 The area where direct placement of topsoil will occur can be extrapolated on a proportionate basis from Volume 1, Table 16-10. As noted in the response to AEP 26, Shell will investigate any opportunities for enhanced use of slash where applicable and economic.

Request 40.2 Please clarify how the use of salvaged mineral soils will vary between the various proposed reconstructed landscapes in the Project Area. Comment on the potential to apply mineral soils across a variety of landscapes to reclaim some of the disturbed areas within the Project Area.

Response 40.2 The salvage and direct placement of mineral topsoils as a reclamation measure is not recommended. The relatively poor quality of the majority of these soils, the small areas within Lease 13 and large-scale equipment typically used in oil sands operations makes this exercise impractical. Leskiw (1997, 1998, pers. comm.) indicates that performance of mineral soils in oil sands reclamation trials appears to be no different than that for the standard "reclamation soil mixture". Unless an advantage in salvaging and replacing mineral soils can be identified, Shell proposes to focus on the use of soil mixtures. This is discussed in the *Terrain and Soil Baseline Report*, Section 5.2, subsection 5.2.4.

Question No. 3.6

Shell No. AEP 41

Issue Geology, Terrain and Soils

Request In Table E7-3, the impact to the Boucher Organic Plain is indicated as irreversible, while Table E7-8 describes it as reversible *(Vol. III, pp. E7-10 and E7-15)*. Please clarify how the Boucher Organic Plain will be reclaimed to existing conditions.

Response The impact to the Boucher Organic Plain should be classified as irreversible in the EIA Volume 3, Part 1, Table E7-8.

Question No. 3.7

Shell No. AEP 42

Issue **Geology, Terrain and Soils**

Request

Fort, Dover and Mildred soils are indicated as being suitable mineral soils for salvage as reclamation materials *(Terrain and Soils Baseline Report, p. 31, Table 9).* Clarify the usefulness of the coarse textured Mildred soils as a reclamation material.

Response

In the *Terrain and Soil Baseline Report*, Section 5.2, it is suggested that mineral soil salvage should be contemplated only if insufficient mineral material is obtained during overstripping of the organic deposits to achieve the desired peat-mineral ratio. Mildred soils alone have little or no value as a reclamation material as they have no A horizon and sandy loam to loamy sand B horizons. These coarse materials might be of some use in enhancing the drainage characteristics of finer textured mineral materials incorporated in the reclamation soil mixture if this is deemed necessary.

Question No. 3.8

Shell No. AEP 43

Issue **Geology, Terrain and Soils**

Request

43.1 Explain why Bitumount soils, which are formed in similar parent material and are often associated with Mildred soils, have not been included as salvageable reclamation material *(Vol. II, p. D8-13, Table D8-7).*

Response

43.1 Bitumount is predominantly Land Capability Class 4 soil, while Mildred is mainly Land Capability Class 3 (Dover is Class 2 and Fort is Class 3). The material balances indicate adequate mineral soil availability for reclamation purposes without salvaging the less productive Class 4 soils.

Request

43.2 Salvaged mineral soil may enhance the establishment of native vegetation and promote biodiversity. Please clarify the research needed to test the difference in vegetation reestablishment between the peat mineral mixes and mineral soils.

Response

43.2 In Section 3.3 in the draft *Guidelines for Reclamation to Terrestrial Vegetation*, potential areas for research are discussed (Summary of Uncertainties and Data Gaps in Ecosite Reclamation and Future Research). Many of these suggestions could form the basis of a future research program:

- The feasibility of using mineral soil through direct placement to develop upland ecosystems needs to be examined.

- The relationship between soil capability classes and vegetation productivity (site index) needs to be identified through monitoring programs.

- The survival and vitality of plant species moved through direct placement from various ecosystems to reclamation sites supporting different subsoils needs to be examined. This could be a comparison of mineral soils and peat mineral mixes.

- The biology and productivity of reclaimed soils should be examined. Mycorrhizae, nutrient cycling and sustainability of peat mineral mix amendments, to ensure that the "living" components of the soil system are functioning effectively and in balance, should be the focus of the reclaimed mineral and peat mineral mixes is suggested.

- Methods to measure biodiversity need to be developed.

- The ability to create ecosites d (low-bush cranberry) and e (dogwood) without adding clay is uncertain. The sustainability of the ecosites needs to be researched.

Question No. **3.9**

Shell No. **AEP 44**

Issue **Geology, Terrain and Soils**

Request

Organic and mineral soil materials were indicated as considered reclamation materials *(Terrain and Soil Baseline Report, p. 28)*. Please comment on the potential value and use of woody debris and slash for reclamation.

Response

RRTAC Report 93-4 - *Organic Materials as Soil Amendments in Reclamation: A Review of the Literature*, Section 3.4: Wood Waste. Indicates major advantages as: reducing evaporation, reducing erosion, retaining moisture and warmth; disadvantages as: relatively inert and decompose slowly - compete with plants for nitrogen (for decomposition), may retard warming up of surface after cold periods, do not stimulate biological activity/nutrient recycling and availability. Given the available volumes of peat within the development footprint there is no need to use coarse woody debris and slash. However, Shell is participating in the regional discussions on alternatives to the burning of waste wood. As the Muskeg River Mine Project develops, Shell will investigate opportunities to enhance the use of slash where applicable and economical. (See OSEC Response 30.)

Question No.	**4.1**		
Shell No.	**AEP 45**		
Issue	**Vegetation and Resources – Assessment**		

Request 45.1 Figures E10-1 and E10-2 illustrate wetland resources linkage diagrams *(Vol. III, p. E10-4)*. Due to the potential change in plant diversity, discuss how a loss or alteration of wetlands related to construction and operation have a linkage to the ecological land classification.

Response 45.1 Losses or alteration of wetlands relate to changes in ecological land class changes because, as discussed in EIA Volume 3, Part 1, Section E7, ELC is an integrated classification framework which considers terrain and soils, terrestrial vegetation and wetlands. (See also linkage diagrams E7-1 and E7-2.)

Request 45.2 Please outline management practices which will be in place to prevent the inundation of wetlands that may result from disrupted surface and subsurface water flows caused by placement of aboveground structures (e.g., dumps).

Response 45.2 The EIA assumes that all wetlands within a 1.5 km perimeter around the mine will be lost due to construction and operation. Therefore, this question only pertains to wetlands near the south overburden dump and the south tailings disposal area. Wetlands in the vicinity of these areas are predominantly treed fens (Ftnn) and swamp (Stnn, Sons) types.

As part of Shell's operational practices, changes in development area lands will be routinely monitored under the conservation and reclamation program. Should surface or subsurface water flow changes result in inundation of wetlands or other areas, decisions on appropriate actions will be made in conjunction with AEP reclamation inspectors. Possible actions would include establishment of small drainage channels to drain excess waters to other mine drainage systems.

Despite these management practices, it is likely that wetlands immediately adjacent to the south overburden and the south tailings disposal area will be impacted to some degree. For the south tailings disposal area, wetlands between the disposal area and the top of the Athabasca River escarpment to the west are likely to be affected, as are wetlands between the disposal area and the Muskeg River and Jackpine Creek to the east.

Incremental impacts are also likely surrounding the south overburden area.

Request 45.3 Table E10-1 presents the direct loss/alteration to wetlands within the Project area and the LSA. Clarify the total loss of wetlands in the LSA and Project area *(Vol. III, p. E10-8, Table E10-1)*.

Response 45.3 Within the LSA, 3,070 ha will be lost due to clearing the project area (Table E10-1) and 665 ha will be lost due to surficial aquifer drawdown (Table E10-2).

Request 45.4 Similarly, impacts to wetlands diversity is delineated in Table E10-11, but is unclear *(Vol. III, p. E10-26, Table E10-11)*. Please clarify.

Response 45.4 Table E10-11 shows the number and size of polygons of each wetlands type in the LSA for pre- and post-disturbance. All wetlands will be reduced in number of patches except bogs. The mean patch size will change for most wetlands except for bogs (Btnn) and shallow open water (Wonn). The range (min-max) in patch size will decrease for wooded swamps (from 0.1 to 38.5 ha to <0.1 to 30.5 ha) and wooded fens (from <0.1 to 63 ha to <0.1 to 50.6 ha). The range in patch size for other wetlands will not be altered as a result of the project.

Request 45.5 This table generally describes impacts to wetland diversity as "long term" in "duration", but reversible *(Vol. III, p. E10-27, Table E10-12)*. Please clarify Shell's rationale for the "reversibility" rating.

Response 45.5 In all wetlands impact classification tables, impacts to fens and bogs are considered irreversible or permanent (Table E10-12). However, shallow open water, marshes, and swamps are expected to re-establish over time following mine closure.

Question No. **4.2**

Shell No. **AEP 46**

Issue **Vegetation and Resources – Assessment**

Request The Wetlands Impact Analysis section addresses magnitude, direction and geographic extent of potential residual impacts on wetlands. With reference to Table E10-6, provide further clarification why Shell considers the residual impact for the swamp categories to be "reversible" and "moderate" in a degree of concern *(Vol. III, p. E10-19, Table E10-6)*.

Response Loss or Alteration of Wetlands:

Impacts on wetlands in the LSA vary depending on the type of wetlands (See EIA Volume 3, Part 1, Table E10-6).

Marshes:

A total of 4.9 ha of marshes, or 5.8% of those in the LSA or less than 1% of those in the RSA would be lost due to site clearing and drainage.

These impacts are classified as negative in direction, low in magnitude, long-term in duration and of low frequency and geographic extent. A low degree of concern is assigned because of the low magnitude of the impact, both in the LSA and the RSA, and because the research currently being conducted by Suncor and Syncrude suggests that marsh wetlands can be reclaimed (Golder 1997).

Shallow Open Water:

A total of 19.9 ha of shallow open water, or 35.1% of these areas in the LSA, or less than 1% of those in the RSA would be lost as a result of site clearing and drainage.

These impacts are classified as negative in direction, high in magnitude for the LSA and low in magnitude for the RSA, long-term in duration and of low frequency and geographic extent. A low degree of concern is assigned because it is expected that shallow open water will be reclaimed following closure. Although in the reclamation scenario all open water was classified as lakes (536 ha) it is expected that littoral zones will most likely emulate shallow open water wetlands classes. Moreover, in the RSA, shallow open water areas are widespread throughout the area.

Swamps:

A total of 675.2 ha of marshes, or 49.3% of these areas in the LSA, or less than 1% of these areas in the RSA would be lost as a result of site clearing and drainage.

These impacts are classified as negative in direction, high in magnitude for the LSA and low in magnitude for the RSA, long-term in duration and of low frequency and geographic extent. The degree of concern for the LSA is high because of the high magnitude of the local impacts and the long-term duration of the effect. The degree of concern for the RSA is low because of the low magnitude of impact. This is because of the widespread occurrence of swamps within the RSA (Halsey and Vitt 1996). It is expected that some swamps will be re-established through reclamation following closure.

The degree of concern for all swamp types in Table E10-6, should read high (not moderate).

Fens:

A total of 2,956 ha of fens, or 57% of these areas in the LSA, or less than 1% of these areas in the RSA would be lost as a result of site clearing and drainage.

These impacts are classified as negative in direction, moderate to high in magnitude for the LSA and low in magnitude for the RSA, long-term in duration and of low frequency and geographic extent. The degree of concern for the LSA is moderate to high because of the moderate to high magnitude of the local impacts and the long-term duration of the effect. These impacts will be ameliorated by the re-establishment of fens through reclamation. The degree of concern for the RSA is low because of the low magnitude of impact.

In Table E10-6, the degree of concern for Fong types should read moderate (not high) .

Bogs:

A total of 1.7 ha of bogs, or 8.5% in the LSA or less than 1% of these areas in the RSA would be lost as a result of site clearing and drainage. The disturbance is exclusively because of surficial aquifer drawdown and not site clearing. These impacts are classified as neutral in direction, low in magnitude for the LSA and the RSA, long-term in duration and of low frequency and geographic extent. The degree of concern for the LSA is nil because of the neutral direction of the effect.

Question No. 4.3

Shell No. AEP 47

Issue Vegetation and Resources – Assessment

Request 47.1 It is stated that "Riparian wetlands will be lost in areas adjacent to the Muskeg River as a result of clearing..." *(Vol. III, p. E10-5)*. It is also stated that approximately 156 ha of riparian shrub complexes will be lost during construction and operation of the Project" *(Vol. III, p. E10-20)*. These statements appear to contradict the statement on page E10-10 which states that "riparian wetlands...that occur along the Athabasca and Muskeg rivers and Jackpine Creek drainages will not be affected due to the Project development" *(Vol. III, p. E10-10)*. Please clarify.

Response 47.1 A total of 156 ha of riparian wetlands along the Muskeg River and Jackpine Creek will be lost as a result of clearance or drainage. No riparian wetlands will be disturbed along the Athabasca River.

Request 47.2 Riparian areas along drainage channels need to be shown on this map in more detail *(Vol. I, p. 16-63)*. Describe the ecosite phase that Shell predicts will revegetate the riparian areas along these channels.

Response 47.2 The riparian vegetation expected to develop along water courses are shrubby marshes or shrubby swamp vegetation communities. The ecosite phase which approximates this class is l1 (marsh).

Mapping this ecosite phase at this conceptual stage of the project is not feasible.

Question No. 4.4

Shell No. AEP 48

Issue Vegetation and Resources – Assessment

Request This table describes predevelopment distributions of forest capability classes (*Vol. III, p. E8-22, Table E8-8*). Please clarify the land capabilities for the disturbance category.

Response The land capability for the disturbance category is Class 5.

Question No. 4.5

Shell No. AEP 49

Issue **Vegetation and Resources – Assessment**

Request "Physiological functions in plants are not negatively influenced until short-term NO_x concentrations reach 2 ppm or greater (Malhotra and Khan, 1984)" *(Vol. III, p. E9-23)*. What plants were used in the study by Malhotra and Khan (1984) to indicate that plants are not negatively influenced until short-term concentrations of NO_x reach 2 ppm or greater?

Response Jack pine and white spruce were used to assess the impact of NO_x (Malhotra and Khan, 1984).

Question No. 4.6

Shell No. AEP 50

Issue **Vegetation and Resources – Biodiversity**

Request This section provides a discussion of the Shannon Diversity Index as a measure of biodiversity *(Vol. III, p. E7-2)*.

50.1 Please discuss the appropriateness of this index as a meaningful measure of biodiversity (diversity and evenness).

Response 50.1 The Shannon Diversity Index was used as an indicator of plant community diversity. This is a commonly used measure of diversity that takes into account the total number of communities as well as the evenness of their distribution (i.e., their relative abundance) (Krebs 1989). A high Shannon diversity score results in situations where there are a high number of communities (or species, depending upon what is being measured) and when the communities are evenly distributed (i.e., all occur with roughly the same frequency). A high Shannon Index score therefore does not necessarily equate with a high level of biodiversity. The Shannon Index is not the best measure of change in biodiversity as it does not identify the loss of rare units. Caution must be used when evaluating richness and diversity indices without considering other factors. Introduction of exotic species to an area will result in an increase in species richness. Similarly, introducing a disturbed patch type to a location, such as through mining, will increase the Shannon Index for the locale, especially if the result is a more even distribution of patch types.

Request 50.2 Provide interpretation of results.

Response 50.2 Interpretation of the results of the biodiversity assessment is difficult and there are no easy answers. The impacts of a reduction in the Shannon Index for macroterrain units at the landscape scale from 1.01 to 0.78 (see Table E7-4), for example, is difficult to assess. As explained in the EIA, the reduction is due to a reduction in the mean macroterrain size from 685 ha to 413 ha and is not due to a reduction in richness. Questions that could be posed include "is the distribution of macroterrain unit sizes following reclamation within the range of sizes found within the region?" and "what implications (if any) does this reduction in mean size have to the ecosystem?". The EIA attempts to document all of the predicted changes but does not elaborate on the potential ecological consequences due to the uncertainty and lack of scientific knowledge concerning these changes. A conservative assumption was made that assumed smaller changes in biodiversity variables are more acceptable than larger changes. Therefore, the mine closure plan attempted to emulate pre-disturbance conditions, in terms of biodiversity, where it was feasible.

Request 50.3 A drop in the index can only be interpreted if it is known how much abundance and evenness are being lost and the identity of lost components. Comment on the effectiveness of the Shannon Index in detecting losses of unique, sensitive and other locally significant units and species.

Response 50.3 The Shannon Index is not particularly useful in detecting losses of unique or sensitive features. Thus, all biodiversity assessment variables (e.g., patch size and range, and other variables as listed in Table E7-1) should be considered when evaluating an impact. Patch (macroterrain and ELC unit) size, patch richness and the Shannon Index were used to analyze impacts to landscape and community level biodiversity in the EIA. Species richness and diversity were used to analyze impacts at the species level. Rare plant potential, the presence of old growth forests, patch size, patch richness and species richness are some measures used to determine the presence of unique units and species, and hence to assess biodiversity, in the RSA and LSA for the EIA. The Shannon Diversity Index is useful, however, for determining targets for reclamation.

Request 50.4 Further demonstrate how the Shannon Diversity Index data can be used to assess whether the impacts of the Project are acceptable.

Response 50.4 The usefulness of the Shannon Diversity Index in assessing the impacts is outlined in the responses to AEP 50.2 and 50.3.

Request 50.5 Table E7-2 describes the macroterrain units within the LSA *(Vol. III, p. E7-9, Table E7-2)*. In the post-development scenario, clarify whether the number of macroterrain units increase from 16 to 17 if disturbed land is included. If so, discuss the potential effect on the Shannon Index calculations.

Response 50.5 There are 17 macroterrain units in the reclaimed landscape and this includes disturbed lands. Therefore, the Shannon Index is based on 17 not 16 units. Introducing a disturbed patch type to a location, such as done for this assessment, will increase the Shannon Index for the locale, especially if the result is a more even distribution of patch types.

Request 50.6 A review of calculations in this table which addresses changes in macroterrain indicates a potential error in the Far Future Shannon Diversity Index. Please check calculations and provide interpretation of results (e.g., increase/decrease in indices value) in the context of impact to biodiversity (*Vol. III, p. E7-11, Table E7-4).*

Response 50.6 The calculations for Table E7-4 were checked and they are correct. The Shannon Index for macroterrain units drops from 1.01 at pre-development to 0.78 post-closure, primarily due to a reduction in mean patch size of natural units and the introduction of a large, reclaimed unit. This effect will likely be lessened somewhat as the reclaimed unit will not be homogeneous. It is likely that the reclaimed areas will represent several macroterrain types and thus the overall macroterrain diversity will not decrease as much as indicated in Table E7-4.

Question No. **4.7**

Shell No. **AEP 51**

Issue **Vegetation and Resources – Biodiversity**

Request Provide and compare target levels of biodiversity from the predisturbance situation, considering factors such as:

51.1 percentages of slope classes, aspect

Response 51.1 Tables that show the change in aspect and slope classes from pre-development to post-development landscapes are presented and discussed in Attachment 1.

Request 51.2 types of topography

Response 51.2 Topography and any alterations resulting from project development were not addressed directly in the EIA in the context of relief. Table E8-1 describes the pre-disturbance and closure distribution of terrain units or landforms, while Tables 2 and 3, in Attachment A provide comparative data regarding the pre-disturbance and closure slope and aspect classes.

Inspection of Table E8-1 indicates that the diversity of terrain units will increase at closure, compared to pre-development conditions. This increase in diversity is caused by an increase in artificial units. The Shannon Index at pre-development (0.84) changes to 1.2 following closure. This increase is slightly inflated because of the breakdown on artificial units in Table E8-1 and does not necessarily reflect an increase in biodiversity.

Request 51.3 types of water columns

Response 51.3 We have assumed the types of water columns refers to the types of wetlands areas.

In the wetland section (E10), open water areas were classified into lakes, rivers, and shallow open water. The impacts are quantified in Table E10-2.

It is apparent from this table that, during the construction and operation phases of the project, the diversity of wetlands will be reduced. Some 3,070 ha will be lost due to clearing and some 665 ha will be altered due to drawdown. A better means of assessing the overall impacts to wetlands is to compare pre-development conditions with conditions following reclamation (Table E10-11). The total number of wetland and lake polygons will decrease from 1,162 at baseline to 862 following reclamation. A loss of diversity will result from the fact that patterned fens will not be reclaimed. Most other wetland classes will maintain their range of patch sizes, i.e., the range of patch sizes following reclamation will be similar to natural conditions.

Request 51.4 soil and subsoil types

Response 51.4 Soil and subsoil types are provided in Table E8-2.

This table indicates that, strictly based on areas, soil diversity will increase following reclamation as no natural soil units will be lost and some man made ones will be created. Obviously, this measure of diversity should not be considered in isolation. The success of the soil reclamation program will depend upon how closely the reclamation soils resemble the natural soils.

Request 51.5 vegetation analysis

Response 51.5 An analysis of vegetation (ELC) biodiversity was provided in the EIA in Tables E7-5 (richness and Shannon Index), E7-6 (number of patches) and E7-7 (mean, minimum and maximum patch size).

Question No. **4.8**

Shell No. **AEP 52**

Issue **Vegetation and Resources – Biodiversity**

Request Table E9-2 describes vegetation types within the LSA and areas to be cleared and reclaimed for the Project. Table E9-2 also shows that 75% of Labrador Tea-subhydric Sb-Pj will be lost.

52.1 Will this place any unique plant species at risk within this ecosite phase? *(Vol. III, p. E9-11, Table E9-2).*

Response 52.1 No unique plants are likely to be put at risk within the Labrador Tea – subhydric Black Spruce - Jack Pine (g1) type. First, this ecosite phase is ubiquitous within the RSA. Second, it comprises species that are represented in other ecosite phases, such as Labrador Tea - Mesic Black Spruce - Jack Pine (c1), Blueberry White Spruce-Jack Pine (b4), Treed Poor Fens (j1) , Treed Rich Fens (j2), and Treed Bogs (I1). Third, although two rare plants (*Coptis trifolia and Rhamnus alnifolia*) were observed within the g1 ecosite phase during the Golder (1997) rare plant survey, both rare plants occurred in survey plots outside the mine development area.

Request 52.2 Please clarify the magnitude of impact on vegetation by providing the percentage of each ecosite phase lost in the study area and ranking them by degree of impact.

Response 52.2 The percent loss or alteration of each ecosite phase within the LSA follows, ranked in order of magnitude of impact:

1. Labrador Tea – Subhygric Black Spruce - Jack Pine (g1) 75%
2. Lichen - Jack Pine (a1) 46%
3. Labrador Tea and Horsetail White Spruce-Black Spruce (h1) 43%
4. Blueberry Jack Pine – Aspen (b1) 38%
5. Blueberry White Spruce – Jack Pine (b4) 34%
6. Low-Bush Cranberry Aspen (d1) 24%
7. Low-Bush Cranberry Aspen - White Spruce (d2) 23%
8. Dogwood and Horsetail Balsam Poplar – White Spruce (e2/f2) 22%
9. Jack Pine Tamarack Complex (a1/g1) 19%
10. Blueberry Aspen – White Spruce (b3) 16%
11. Labrador Tea - Mesic Jack Pine - Aspen (c1) 15%
12. Dogwood Balsam Poplar – Aspen (e1) 15%
13. Blueberry Aspen (b2) 0%
14. Low-Bush Cranberry White Spruce (d3) 0%
15. Dogwood and Horsetail Poplar - Aspen (e1/f1) 0%
16. Dogwood Balsam Poplar – White Spruce (e2) 0%
17. Dogwood White Spruce (e3) 0%

The residual impacts on terrestrial vegetation are provided in Table E9-2 (see Attachment 2). A total of six terrestrial ecosite phases (b2, b3, b4, d1, d2 and e3) will be reclaimed following mine closure. The reclaimed ecosites will offset the losses to some ecosite phases.

Question No. **4.9**

Shell No. **AEP 53**

Issue **Vegetation and Resources – Biodiversity**

Request 53.1 Information is presented on ecosite phase, species richness, and rare species *(Vol. II, p. D9-5)*. This section states that "Species richness and diversity indices were not calculated because only a few of the ecosite phases were represented by a sufficient number of plots to allow meaningful statistical comparisons". Provide baseline data on species richness and diversity for all ecosite phases of aquatic and terrestrial vegetation types that will be disturbed by the mine development. Adjust Section D9.2.6 accordingly if surveys find additional information is warranted.

Response 53.1 Total species richness and information on rare plant species from combined plots are provided in Table D9-3, D9-4 and D9-5 for terrestrial vegetation and in Tables D10-4, D10-5 and D10-6 for wetlands.

Request 53.2 It is not clear why species richness is presented in Table E9-14 *(Vol. III, p. E9-30, Table E9-14)*. Is the critical factor the total number of species found in the ecosite, rather than their distribution through an unknown number of plots of unknown size? Similarly, explain how the diversity of individual plots is an important factor. Describe the diversity of the ecosite phase as determined from the combined plots.

Response 53.2 Table E9-14 shows the number of species observed per plot in the ecosite phases. This information is useful for determining reclamation targets for ecosite phases, where similar plots will be used to measure reclamation success. Diversity measurements were calculated on combined plots not individual plots. The number of species (i.e., richness for each ecosite phase) is provided in Attachment 3.

Request 53.3 This table appears to present the average, minimum, and maximum number of species per plot in each type *(Vol. III, p. E10-23, Table E10-8)*. Provide the breakdown of species per the Alberta Wetlands Inventory (AWI) types that exist in wetland areas affected, but are not shown in the table (e.g., Stnn, Sfnn, Sons, Wonn, Mong, Bons, Btni, Nwl, Nwf, and Nwr).

Response 53.3 The species observed within each AWI class are provided in the Supplemental Table 2 to Attachment 4. There were no Bons or Btni wetlands observed in the local study area (LSA), so these are not included. There were no vegetation surveys in lakes (Nwl), flooded areas (Nwf) or rivers (Nwr).

Request 53.4 This table gives the mean and range of species diversity values for individual plots within the ecosite phases *(Vol. III, p. E10-24, Table E10-9)*. This table does not represent a diversity index for the ecosite phase. What is of interest is the combination of the plots (e.g., where "Pi" = the proportion of plots that species "i" was found in). The "Pi" used here is the proportion of individuals of species "i" in the plot. Please provide Shell's views on this comment and provide an alternative, if appropriate.

Response 53.4 Table E10-9 does represent the diversity index for each ecosite phase not each individual plot. All plots occurring within each ecosite phase were combined to calculate the diversity values presented.

The total number of species observed per ecosite phase is shown in Attachment 3.

Question No. **4.10**

Shell No. **AEP 54**

Issue **Vegetation and Resources – Biodiversity**

Request 54.1 Table E9-1 indicates a total loss of vegetation in 45.7 per cent of the LSA, however, Shell concludes in Table E9-8 that residual impacts on plant communities have a "low" degree of concern *(Vol. III, p. E9-9, Table E9-1; p. E9-21, Table E9-8)*. This suggests a minimal loss or alteration of the vegetation communities. Please clarify Shell's rationale for this conclusion. As well, explain further the "reversibility" rating and the "low" degree of concern for rare and endangered and traditional use plants.

Response 54.1 An overall loss of 45.7% does not necessarily translate to a high degree of concern if particular terrestrial plant communities are not common within the areas cleared, or if the communities are common in the RSA, or if they can be readily replaced through reclamation.

The degree of concern for the loss of Aspen–White Spruce forest should be corrected in Table E9-8. The actual degree of concern is low to moderate, which reflects the low to moderate magnitude of impact to this forest type.

The degree of concern for rare and endangered plants or communities is low as no rare plants or communities were found within the project footprint.

The degree of concern for traditional use plants should be stated as low to moderate in Table E9-8. This rating reflects the low to moderate magnitude of impact to these plants.

Reversibility for traditional use plants refers to the fact that once the landscape and soils are reconstructed, the understory vegetation, which would be supported in plant communities that will become established, would provide traditional use plants. Rare plants might or might not become re-established, depending on the availability of seeds or other propagules. Therefore, the rating for rare plants should be reversible or irreversible.

Request 54.2 Discuss Shell's rationale for determining impacts on terrestrial vegetation Key Indicator Resources (KIRs) as reversible. Discuss the technology and capability of Shell to re-establish the KIRs, or alternatively, the commitment and research to enable this to happen.

Response 54.2 The *Oil Sands Vegetation Reclamation Committee Report* (1998) outlines the vegetation communities that should re-establish on reconstructed soils. Based on reclamation research and monitoring results of the existing oil sand operators, the vegetation KIRs associated with these vegetation communities are expected over time to invade the reclaimed landscapes. There is still uncertainty about optimal methods to be used to reclaim CT. Shell will participate in the terrestrial reclamation research programs being conducted under CONRAD to define the best approaches for reclaiming CT. Shell will establish vegetation monitoring plots on its reclaimed sites.

Request 54.3 Shell has concluded that none of the four rare plants associated with the terrestrial habitat will be affected by the Project *(Vol. III, p. E9-15)*. Does this reflect a lack of sampling?

Response 54.3 Four rare plants identified are associated within uplands (terrestrial) habitat (not wetlands). None of the upland (terrestrial) rare plants were observed in the mine development area (from page E9-15).

Sampling was adequate for the assessment. Two rare plant inventories were undertaken in the LSA. Bovar (1996) conducted rare plant surveys in the third week of June and the fourth week of July, 1995. Golder conducted a rare plant inventory for the Muskeg

River Mine project EIA in July, 1997.

Request 54.4 The rare plant list appears to have been collected from existing literature *(Vol. II, p. D9-5)*. Please indicate which ecosite types were used to verify the species listing.

Response 54.4 Westworth (1990) in the report Environmentally Significant Areas etc. claimed that all rare plants were observed in fens as stated in the EIA. Fen ecosite phases include k1, k2, k3, j1 and j2. However, wetlands were mapped according to the Alberta Wetland Inventory (AWI). The fens represented in this classification include wooded fens (Ftnn/Fenn), graminod fens (Fong) and shrubby fens (Fons).

Three rare plants associated with wetlands (fen) habitats were found in the mine development area.

Request 54.5 Outline Shell's rare plant reclamation proposal to support the claim of short term, reversible impact.

Response 54.5 A rare plant reclamation strategy is unnecessary given the low degree of concern for impacts to this group. It is expected that natural invasion of species from undisturbed areas, and the availability of seeds and rootlets in the reclaimed soils will assist in the reclamation program so that a natural mix of species will eventually occur on the reclaimed landscape. See the response to AEP 54.1 for a discussion on reversibility.

Question No. **4.11**

Shell No. **AEP 55**

Issue **Vegetation and Resources – Biodiversity**

Request Section E9.4.1 indicates that species richness and diversity have been used to evaluate biodiversity for the Project *(Vol. III, p. E9-3)*. In Vol. II, Section D9, Shell has indicated this assessment to be inadequate and that more study is necessary. Please comment on the appropriateness of further study which includes:

55.1 all vegetation species

Response 55.1 Shell did not state that the assessment was inadequate. A statement beneath Table D9-4 refers to an inability to find statistically significant relationships between rare plants and vegetation units. The data collected during the field survey, plus the data collected by others in the region, allowed for a rare plant potential to be assigned to each ecosite phase. The rare plant potential rating system was developed based on the recommendations by the Alberta Natural Heritage Information Centre (ANHIC) (see response to AEP 58.5 for more details. Hence, further studies are not necessary.

Request 55.2 maps and analysis of ecosite phases, vegetation polygon-sizes, arrangements and associations

Response 55.2 Maps and analyses of ecosite phases, vegetation polygon sizes, arrangements and associations are provided in Volume 3, Part 1, Section E9.

Request 55.3 all the fauna components

Response 55.3 Fauna are described in Volume 3, Part 1, Section E11.

Question No. **4.12**

Shell No. **AEP 56**

Issue **Vegetation and Resources – Ecosite Analysis**

Request

Twenty m^2 assessment plots were used for each ecosite type to determine the baseline list of plant species *(Vol. II, p. D9-5)*.

Please clarify the survey intensity for each ecosite phase. Indicate the level of confidence that the species shown accurately reflect the species that exist in each ecosite phase.

Response

The vegetation and wetlands baseline reports provide a description of the methodology and field techniques employed to evaluate vegetation communities and plant species in the LSA. Experienced field staff followed the *Ecosites of Northern Alberta* guidelines to identify ecosite phases based on species associations and site conditions. Species lists for each ecosite phase are provided in Attachment D. The survey intensities for each ecosite phase are identified in Attachment E. The intensity was adequate for most ecosite phases, that is, there is a high level of confidence that the species shown accurately reflect the species that exist in most ecosite phases.

Question No. **4.13**

Shell No. **AEP 57**

Issue **Vegetation and Resources – Ecosite Analysis**

Request

The number and the size of ecosite phase polygons represented in Table E9-13 *(Vol. III, p. E9-29)* do not appear to correspond with the conceptual map *(Vol. I, p. 16-63)* which shows the reclaimed landscape. Please clarify.

Response

EIA Volume 3, Part 1, Tables E9-12 and E9-13 on vegetation polygons or patches provide information for ecosite phases throughout the LSA. Volume 1, Section 16, Figure 16-16 details ecosites for only the reclaimed sections of the LSA. Not all ecosite phases within the LSA will be found in the reclaimed areas.

A comparison of ecosite phases projected to be disturbed with those expected to be reclaimed (Table E9-18) shows a close correspondence with the conceptual closure design.

Question No.	**4.14**
Shell No.	**AEP 58**
Issue	**Vegetation and Resources – Ecosite Analysis**

Request Table E9-15 implies that the number of individuals of each species were counted in each plot, thereby facilitating the calculations *(Vol. III, p. E9-3)*.

58.1 Clarify how sampling discriminates between individuals. Is it the number of individuals in a plot that is of relevance, or the occurrence of a species between plots?

Response 58.1 The Shannon Diversity Index requires a measure of abundance. Abundance was calculated using percent cover measurements not from counting the number of individuals in each plot. The relevance is to provide a description of ecosite phases surveyed within the LSA. Ecosite phases that have rare species are listed in Tables D9-5 and E10-3.

Request 58.2 Please clarify which ecosites have the uncommon species. Consider:

Response 58.2 The province does not have an "uncommon" designation for plants.

Request 58.3 method descriptions

Response 58.3 The methodology for plant community assessment field methods is described in Section D9.2.3. Plot sample sizes for each ecosite phase are provided in Attachment 3, while species lists found within each ecosite phase are provided in Attachment 4. Additional methodology is provided in the baseline vegetation and wetland reports.

Request 58.4 complete species lists and richness for each ecosite phase

Response 58.4 A complete species list for each ecosite phase is provided in Attachment 4 and species richness is presented in Attachment 3.

Request 58.5 determination of the most unique ecosite phases

Response 58.5 Unique ecosite phases were defined to include those phases that have a high potential for rare plants, those that were found to be rich in species, and those that were found to have old growth stands.

Rare Plant Potential Rating System:

A rare plant potential was assigned to each ecosite phase based on 1997 field observations (Table E9-5) and other rare plant surveys within the regional study area that documented rare plant habitat. A rare plant potential rating system was developed based on the recommendations by the Alberta Natural Heritage Information Centre (ANHIC).

No Potential: Habitat characteristics do not favour the establishment of rare plants. These areas often have dense, highly competitive and established communities or are areas under cultivation.

Low Potential (L): These areas are generally part of large tracts of land with similar vegetation communities and ecological settings.

Moderate Potential (M): Habitats altered by natural forces, such as eroded slopes or exposed rock outcrops, and areas with different slope aspects in rolling terrain. These areas often have sparse vegetation cover, less aggressive or competitive species and soil conditions that make plant establishment difficult.

High Potential (H): Habitats that were different from those in the same general area - alkaline wetlands, stream crossings or islands of native vegetation within large tracts of cultivated or disturbed lands, which contain associations of uncommon or unusual plant species.

Rare plant potential is assigned to the following upland ecosite phases:

- Lichen - Jack Pine (a1) L
- Jack Pine Tamarack Complex (a1/g1) M
- Blueberry Jack Pine – Aspen (b1) H
- Blueberry Aspen (b2) M
- Blueberry Aspen – White Spruce (b3) M
- Blueberry White Spruce - Jack Pine (b4) H
- Labrador Tea – Mesic Jack Pine – Aspen (c1) L
- Low-Bush Cranberry Aspen (d1) L
- Low-Bush Cranberry Aspen - White Spruce (d2) M
- Low-Bush Cranberry White Spruce (d3) H
- Dogwood Balsam Poplar - Aspen (e1) H
- Dogwood and Horsetail Balsam Poplar - Aspen (e1/f1) H
- Dogwood Balsam Poplar - White Spruce (e2) H
- Dogwood and Horsetail Balsam Poplar - White Spruce (e2/f2) H
- Dogwood White Spruce (e3) H
- Labrador Tea – Subhygric Black Spruce - Jack Pine (g1) M
- Labrador Tea and Horsetail White Spruce - Black Spruce (h1) M

Lowland ecosite phase rare plant potential ratings are provided in Table E10-4 of the EIA. In general fens and bogs were rated as High for rare plant potential.

Species Richness:

Attachment E provides the number of species found per ecosite phase during field work. The 10 ecosite phases in Table 58-1 were considered to be unique because of their above average number of species:

The Lichen-Jack Pine (a1) ecosite phase was the only phase found to contain old growth forest.

Table 58-1 : Plant Ecosite Phase and Number of Species

Class	Ecosite Phase	Number of Species
b1	Blueberry Pj-Aw	56
d1	Low Bush Cranberry Aw	73
d2	Low Bush Cranberry As-Sw	71
e1	Dogwood Pb-Aw	58
g1	Labrador Tea Subhygric Sb-Pj	51
j1	Treed Poor Fen	62
k1	Treed Rich Fen	78
k2	Shrubby Rich Fen	87
FONS	Shrubby Fen	101
FTNN and FFNN	Treed Fen	97

Request 58.6 calculation of the proportion of each species expected to be lost

Response 58.6 The calculations are based on changes to ecosite phases, not individual species.

Question No. **5.1**

Shell No. **AEP 59**

Issue **Wildlife – Assessment**

Request Shell indicates that a multi-plate, large diameter, culvert type of structure is the preferred crossing of the Muskeg River *(Vol. I, p. 4-11)*.

59.1 Describe the potential impact from construction associated with this structure on fisheries habitat or wildlife movement along the river.

Response 59.1 Since filing the application, Shell has further explored options for crossing the Muskeg River. Shell has selected a three-span bridge for the crossing (see Section 4.2, Water Management in the Project Update). This will minimize impacts to fish and wildlife.

Request 59.2 Clarify the mitigation required to minimize impacts, should this crossing be necessary.

Response 59.2 See the response to AEP 59.1.

Question No. 5.2

Shell No. AEP 60

Issue **Wildlife – Assessment**

Request

Shell states that "For moose and black bears, different disturbance coefficients (DCs) were established depending on whether or not the vegetation adjacent to the disturbance represents adequate cover or not (USDA Forest Service)" *(Vol. III, p. E11-9).*

Please clarify why different DCs were established for moose and black bear dependent upon habitat quality. Will disturbance have the same relative impact regardless of the cover of the habitat suitability index (HSI) rating?

Response

Different DCs were established based on cover values only, not food quality or total quality. It was assumed, as it was assumed for the USDA grizzly bear CEA model, that disturbance would have a greater impact (and thus a larger DC) in areas with low cover.

While this could be construed as "double counting" of cover values, it was included in the moose and bear models to emphasize the role that cover can play in ameliorating or exacerbating the effects of human-caused disturbance.

Question No. 5.3

Shell No. AEP 61

Issue **Wildlife – Assessment**

Request

This section suggests that "Removal of Low suitability habitat throughout the development of the proposed Project in itself is not considered detrimental to moose..." *(Vol. III, p. E11-30).*

61.1 All habitats contribute to species carrying capacity in some way, and removal of "low" suitability habitat may have a detrimental impact to wildlife. Provide Shell's perspective on this.

Response

61.1 The sentence quoted is in error. It should read "Removal of Low suitability habitat throughout the development of the proposed project, while detrimental to the carrying capacity of the area for moose, is not as detrimental as would be the removal of Moderate or High suitability habitat".

Request

61.2 It is stated that "if key riparian and upland habitats that connect habitat patches are left undeveloped, such areas will serve to channel moose movement." *(Vol. III, p. E11-50 and 51).* The Athabasca and Muskeg River valleys are designated as key moose areas for winter habitat. Identify where significant local habitat, seasonal habitat use, winter and summer range, and movement corridors for moose and other key indicator species exist and which ones will be removed by Project development.

Response 61.2 Areas of High, Moderate and Low suitability KIR habitat to be removed for 12 species are identified and illustrated in the HSI report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*. Figures of habitat loss for moose, beavers and western tanagers are also provided in EIA, Volume 3, Section E11, Figures E11-7, E11-9 and E11-11. Figures of habitat loss for all KIRs are provided in the HSI report (this report was not available at the time of the submission of the EIA).

HSI models were created for the seasons of the year determined to be most critical to each species, as follows:

- beaver (summer)
- black bear (summer)
- Cape May warbler (summer)
- dabbling ducks (summer)
- fishers (all year)
- great gray owl (all year)
- moose (winter)
- pileated woodpecker (all year)
- red-backed vole (all year)
- ruffed grouse (all year)
- snowshoe hare (winter)
- western tanager (summer)

Key wintering areas for moose within the Athabasca River valley will not be impacted by the project footprint. A discussion of moose movement corridors, to the extent that they are known, is provided in Section 5.1.1 of the report *Wildlife Baseline Conditions for Shell's Proposed Muskeg River Mine Project*. In summary, moose studies in the area have shown that most seasonal moose movements occur in a west -east direction and that movements along the Athabasca River are not prevalent. Baseline work also showed that riparian areas are important to moose and that these areas likely act as movement corridors. Mitigation for the EIA includes the creation of wildlife corridors along the Muskeg and Jackpine valleys. These should serve to protect this important moose habitat. These corridors would also serve as habitat and conduits for many other species.

Request 61.3 Shell indicates that "restoration and reclamation should enable moose to repopulate the site *(Vol. III, p. E11-35)*. Indicate how reclamation will be undertaken to enhance habitat attributes for moose and other wildlife species. Show how riparian areas might be designed (e.g., sinuosity, revegetation) to provide wildlife habitat and travel corridors in the reclaimed landscape.

Response 61.3 Target vegetation types for reclaimed areas have been selected with moose and other KIRs in mind. For example, b1 (Blueberry-Jack Pine-Aspen) provides good moose cover while d1 (Low Bush Cranberry-Aspen) provides good moose food. Reclamation will include the planting of species that are beneficial for KIR food and cover (e.g., willows for moose food, spruce for moose cover).

Riparian areas will be revegetated in patterns (e.g., in terms of sinuousity and cover values) similar to those found under baseline conditions.

The habitat suitabilities that would be provided by the types and distribution of vegetation communities identified in the closure plan were modeled for KIRs (see the report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*).

Question No. **5.4**

Shell No. **AEP 62**

Issue **Wildlife – Assessment**

Request

Shell indicates that mitigation for impact caused by development induced hydrological changes will be achieved primarily by reclamation *(Vol. III, p. E11-48)*. Shell further notes that the creation of the end pit lake and numerous small wetlands are proposed for closure and will have a net position effect on wildlife. Please substantiate this statement.

Response

Impacts due to localized water table drawdown will ameliorate over time following closure as surficial aquifers re-establish and the water table rises.

Creation of the end-pit lake, wetlands and riparian habitat will be positive for species such as dabbling ducks and beavers. Habitat requirements for these species are described in the baseline wildlife report *Wildlife Baseline Conditions for Shell's Proposed Muskeg River Mine Project* and specific habitat variables for KIRs are provided in the report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project.*

The quality of the end-pit lake water will be monitored to ensure it is acceptable for use by wildlife. Reclamation activities around the borders of the lake and wetlands will provide the habitat requirements for KIRs that use these areas. For example, revegetation of beaver habitat will include the planting of deciduous trees and shrubs.

Question No. **5.5**

Shell No. **AEP 63**

Issue **Wildlife – Assessment**

Request

63.1 Table E11-8 states that the "duration" of construction and operation-related residual impacts to wildlife habitat is "moderate" *(Vol. III, p. E11-62)*. In reference to Table E1-9, Impact Description Criteria *(Vol. III, p. E1-21)*, there is no "duration" criteria indicated as "moderate".

Please clarify why the "duration" criteria "moderate" was used in Table E11-8. Since it may take up to 30 years before a return of significant viable habitat for most wildlife species, indicate Shell's rationale for this rating.

Response 63.1 Revised tables for Section E11 are in Attachment 5 at the end of this section. Duration has been changed to long-term.

Request 63.2 Discuss the potential impact to wildlife foraging within the LSA in the near future and indicate Shell's rationale for not rating this impact as "long-term" *(Vol. III, p. E11-96, Table E11-15)*. Table E11-15 describes residual impacts on wildlife abundance and diversity as "moderate duration". Provide similar clarification and rationale.

Response 63.2 Table E11-15 was in error. See the revised tables for Section E11 in Attachment 5 at the end of this section. The duration has been changed to long-term.

Request 63.3 Table E11-19 presents a summary of wildlife residual impacts and degrees of concern *(Vol. III, p. E11-112, Table E11-19)*. Provide Shell's rationale for rating the "duration" as "moderate" as opposed to "long term".

Response 63.3 Table E11-19 was in error, as were some of the other tables in Section E11. The revised tables for Section E11 are included at the end of this section (Attachment 5). The duration has been changed to long-term.

Tables have been clarified to show whether reclamation was considered.

Question No. **5.6**

Shell No. **AEP 64**

Issue **Wildlife – Assessment**

Request Table E11-17 lists Exposure Ratio (ER) exceedances for the reclaimed landscape which appear to be significant (e.g., vanadium =262 per cent for 90th percentile ER) *(Vol. III, p. E 11-107)*. Please clarify.

Response ER values for barium and vanadium exposures to deer mice were marginally greater than 1.0. In addition, the 90th percentile ER value for molybdenum exposure to moose was marginally greater than 1.0. However, these marginal exceedances are not indicative of an impact to wildlife health. Rather, these exceedances were interpreted in terms of the conservatism and uncertainty associated with the assessment. Based on these considerations, in the opinion of the risk assessors, ER values between 1 and 10 are not considered problematic. Some examples of conservatism include:

- confinement of moose to LSA boundaries, despite larger home range
- exposures to reasonable maximum concentrations in all media at the 90th percentile
- combined exposure to water, terrestrial plants, aquatic plants, terrestrial invertebrates and

aquatic invertebrates (based on dietary requirements) every day of the year for their entire lifespan

ER values for these chemicals were less than 10. Therefore, no impacts to wildlife health are predicted for these chemicals.

Question No. **5.7**

Shell No. **AEP 65**

Issue **Wildlife – Assessment**

Request

Shell states that "... due to the uncertainty regarding the potential chronic effects of naphthenic acid present in water releases..." *(Vol. III, p. E11-108)* and "...However, some uncertainty exists with respect to chemical uptake into plants grown in overburden or tailings sand and chemical concentration in reclamation materials" *(Vol. III, p. E11-109)*. There appears to be significant uncertainty with respect to predictions. Please explain how this uncertainty will be resolved.

Response

See the responses to AEP 143 and 144 for a discussion of naphthenic acids.

Shell is also participating through CONRAD in industry research on the effects of CT and reclamation materials on terrestrial landscapes. Through membership in these committees, Shell will continue to participate in ensuring that studies are being conducted to resolve the uncertainties associated with chemical exposures on reclaimed landscapes. Some of the current programs include:

- Phytotoxicity of Reclaimed Fine Tails and Tailings Sand (includes CT) – work by University of Alberta.
- Consolidated Tailings Release Water Wetlands Study - work by University of Alberta, Simon Fraser University, University of Saskatchewan, Canadian Wildlife Service, University of Windsor and Golder Associates.
- Effects of CT deposits and release water on terrestrial plants - work by University of Alberta and Golder Associates.

Question No. **5.8**

Shell No. **AEP 66**

Issue **Wildlife – Assessment**

Request

Shell outlines the need for monitoring habitat/wildlife as critical to achieving wildlife mitigation *(Vol. III, p. E11-61)*. Please describe the habitat/wildlife research necessary to determine if target habitat units are being achieved. Include a schedule for the research.

Response

Shell assumes that research was meant to be 'monitoring' in this question. Recommended monitoring programs for wildlife habitat and populations are as follows:

- monitoring of type, abundance, patch size and patch distribution of plant communities
- monitoring of biophysical parameters that were used in the KIR habitat models
- wildlife surveys (e.g., aerial surveys, browse and pellet group counts, track counts) to determine wildlife use of reclaimed areas

Details of the monitoring program, such as schedule, will be defined by Shell's internal monitoring committee (see the response to AEP 35).

Question No. 5.9

Shell No. AEP 67

Issue Wildlife – Assessment

Request

Shell references the *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan* (IRP) which indicates that there must be a demonstration of impact mitigation on a number of resources and values within the river valley *(Vol. III, p. E16-9)*.

Illustrate how reclamation of the Project will meet the Broad Wildlife Objectives as identified in the IRP for the Sub-Region, as well as, for the *Athabasca-Clearwater Resource Management Area* (RMA). Demonstrate how re-establishment of habitat will meet these objectives, as well as, provide benefits for a broad range of wildlife species.

Response

The broad wildlife objectives as identified in the IRP are to:

1. Minimize damage to wildlife habitat, and, where possible, to enhance the quality, diversity, distribution and extent of productive habitat.
2. Maintain, and, if possible, enhance the diversity, abundance and distribution of wildlife resources for Native subsistence, recreational and commercial benefits. Such resources include the black bear, ungulates, bird game and furbearers.
3. Protect species considered to be sensitive to disturbance or environmental change (e.g., pileated woodpecker) and to promote increased populations and distribution of species considered rare or endangered (e.g., wolverine, woodland caribou).
4. Promote and develop opportunities for both consumptive and nonconsumptive uses associated with wildlife.
5. Promote the use of the fur resource within its capability, and, at a minimum, to maintain the trapping industry at its current level.
6. Promote activities and methods that will minimize the number and costs of nuisance wildlife events.

Mitigation for the Muskeg River Mine Project will address these six objectives as follows:

1. The Muskeg River Mine Project EIA addresses impacts to 12 key species that were selected based on political, commercial and subsistence economic importance, non-consumptive importance and ecological importance. The objectives of the IRP were considered as part of the selection process. HSI modeling was conducted for all 12 key species. The selected species included some that are specifically mentioned in the IRP, i.e., the moose, black bear, fisher, beaver, ruffed grouse and pileated woodpecker. Other species were selected to represent others mentioned in the IRP, e.g., ruffed grouse and dabbling ducks represent bird game, great gray owl represents raptors (see Volume 2, Page D11-2). The development's footprint was minimized to reduce impacts to wildlife species and reclamation planning was conducted with the habitat requirements of the KIRs in mind. While habitat conditions are predicted to be improved over baseline conditions for some species, and reduced for others (e.g., wetland species), the overall predicted change in HUs for all KIRs combined is positive under the reclamation scenario (see Table 97 in the report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*). Thus, the residual impact on habitat for all KIRs combined is positive.
2. Mitigation for both population and habitat impacts to these species was provided in the EIA. For example, no hunting will be allowed by Shell employees or contractors while on site.
3. The pileated woodpecker and other species considered to be sensitive to disturbance were included as KIRs. There are no woodland caribou within the LSA; fishers were chosen to represent terrestrial furbearers such as the wolverine, in part because they are easier to monitor than the wolverine.
4. KIRs selected for the EIA were chosen, in part, for their consumptive and non-consumptive values. The EIA predicts that there will be a net gain in habitat for KIRs (when all 12 are considered together).
5. Fishers, beavers and the black bear were considered as KIRs for the EIA.
6. Specific mitigative recommendations regarding nuisance wildlife (e.g., strict garbage control to reduce bear-human interactions) were provided in the EIA.

Question No. **5.10**

Shell No. **AEP 68**

Issue **Wildlife – Assessment**

Request

This section discusses vulnerable, threatened and endangered species *(Vol. II, p. D11-7).*

Please provide further clarification on the habitat requirements, seasonal use and significant areas for rare and endangered species in the Local Study Area (LSA). Indicate which of these species are found in the LSA. Indicate whether reclamation measures are likely to be effective in habitat restoration and why.

Response

The habitat requirements and value of the LSA for vulnerable, threatened and endangered wildlife species are provided in Table 68-1. The species likely to occur within the LSA are also listed in Table 68-1.

Table 68-1: Habitat Requirements, Potential Value of the LSA and Predicted Success of Planned Reclamation Activities for Vulnerable, Threatened and Endangered Species Expected to Occur Within the LSA

Species	Habitat Requirements	Value of LSA	Success of Reclamation
Canadian toad	Boreal and parkland habitats; breeds in ephemeral and permanent, shallow waterbodies	Low due to the low number of suitable breeding areas	Reclamation of the development area would not be expected to restore all toad breeding habitat as, in general, more upland than lowland habitat will be reclaimed. It is likely that the loss of toad breeding habitat relative to baseline conditions would be of the same order of magnitude as losses for other wetland dependent KIRs such as the beaver (projected loss of 6% over baseline). However, no habitat modeling was conducted for the toad. Reclaimed ponds and lakes will be designed, in part, to satisfy the breeding requirements for toads. Monitoring of toad populations during reclamation will be undertaken to assess the efficacy of these measures
Whooping crane	Large ponds and lakes for migratory stopovers	Limited value due to small size of waterbodies	Reclamation for whooping crane habitat was not considered during closure planning
Short-eared owl	Open areas with sloughs and marshes	Presumed to be similar to value for great gray owls; although these owls nest in open areas	Presumed to be similar to success for great gray owls (+17%). Monitoring undertaken during reclamation will ascertain how effective reclamation will be for this species
Great gray owl	Popular pine and spruce forests; forages in openings such as meadows and marshes	HSI modeling indicated that the LSA has 2,559 HUs for this species. This represents 23% of the total possible HUs that could occur within the LSA	HSI modeling predicts an increase of habitat suitability of 17%. Therefore, reclamation is expected to be effective for this species
Ferruginous hawk	Plains and prairies (not a boreal species)	Low due to the forested nature of the LSA; LSA is on the edge of this species range	Likely no change in suitability. this is not a priority species as the LSA is on the fringe of its range
Peregrine falcon	Nests in cliffs; prefers open country with shores and marshes frequented by shorebirds and waterfowl	Low due to the lack of suitable nesting sites and low numbers of waterfowl	Suitability may increase as dabbling duck habitat is predicted to increase by 43%; however, lack of suitable nesting sites is probably limiting
Cape May warbler	Old growth forest	HSI modeling indicated that the LSA has 1,583 HUs for this species. This represents 14% of the total possible HUs that could occur within the LSA	HSI modeling predicts an increase of habitat suitability of 51%. therefore, reclamation is expected to be effective for this species
Bay-breasted warbler	Old growth forest	Presumed to be similar to value for Cape May warblers	Presumed to be similar to success for Cape May warblers (+51%). Therefore, reclamation is expected to be effective for this species. Monitoring during reclamation will determine whether this species will successfully recolonize the site

Black-throated green warbler	Old coniferous forest	Presumed to be similar to value for Cape May warblers	Presumed to be similar to success for Cape May warblers (+51%). Therefore, reclamation is expected to be effective for this species. Monitoring during reclamation will determine whether this species will successfully recolonize the site
Wolverine	Uses wide range of habitats	Presumed to be similar to value for fishers	Presumed to be similar to success for fishers (+7%). Therefore, reclamation is expected to be effective for this species. Monitoring during reclamation will determine whether this species will successfully recolonize the site

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Question No. **5.11**

Shell No. **AEP 69**

Issue **Wildlife – Assessment**

Request

Habitat and wildlife use in the reclaimed landscapes are addressed *(Vol. III, p. E16-35).* Shell states that "Wetland communities were selected to conform to the IRP guidelines regarding moose habitat"

69.1 Please clarify this statement in the context of Shell's comment that moose habitat within the LSA is expected to increase 10 per cent over baseline conditions following closure, partially due to the "recreations of upland habitats..." *(Vol. III, p. E11-97).*

Response

69.1 The HSI model for the moose incorporates food and cover variables for both uplands and lowland habitat and looks at the overall suitability of the landscape. Moose habitat suitability can be quite high in upland habitats, particularly if the habitat is close to water or wetlands. While more upland habitat will result following closure of the mine, it does not follow that the overall habitat suitability will be less. The lakes and wetlands planned for the post-closure conditions will contribute to the overall habitat suitability of the landscape.

Request

69.2 Provide a comparison of pre-disturbance and post-disturbance wetland suitability for moose habitat.

Response

69.2 A comparison of wetland versus upland HUs for moose would be difficult because of the spatial nature of the model; the landscape must be treated as a whole. However, a comparison of the pre-disturbance and reclaimed wetland habitats was done and is shown in Table 69-1.

Table 69-1: Comparison of Hectares of Predisturbance and Reclaimed Wetland Habitats

Vegetation	Baseline (ha)	Reclaimed (ha)
Open water	177	747
Bogs	20	20
Fens	5,183	2,697
Marshes	885	80
Swamps	708	344
Shrubby swamps	793	823
Total	7,766	4,711

Question No. 5.12

Shell No. AEP 70

Issue **Wildlife – Assessment**

Request Shell indicates that, for the assessment of wildlife habitat, the temporal boundaries for the Cumulative Effects Assessment (CEA) were confined to the construction phase and that this was considered to be a conservative approach, as effects for that period represent the maximum cumulative effects possible *(Vol. III, p. F11-2)*.

Provide information on the cumulative impacts to wildlife related to operational and closure phases of the development. Please provide further understanding of Shell's rationale for limiting the CEA to the construction phase.

Response The focus of the CEA wildlife assessment was to assume the maximum disturbance that will arise from both the construction and operation phases of all of the developments, and not to consider positive effects due to reclamation. This was a conservative approach. Closure (reclamation) modeling could not be undertaken as conceptual reclamation plans were only available for a few mines.

Question No. 5.13

Shell No. AEP 71

Issue **Wildlife – Assessment**

Request The linkages between site clearing and removal or alteration of vegetation communities and impact on wildlife are examined. Shell notes the limited amount of high quality of dabbling duck habitat within the LSA and states that "these impacts can all be expected to have a negative effect on dabbling duck populations in the Project area…"*(Vol. III, p. E11-41)*. Describe how construction activities might be modified around critical wildlife periods, such as for breeding season and for avian species to minimize impacts.

Response The dabbling duck habitat that will be impacted by the development consists of two small ponds and some nearby wetlands (Figure 15 in *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*). These areas were not found to support high numbers of ducks and, therefore, there will be no need to modify construction activities.

Question No. **5.14**

Shell No. **AEP 72**

Issue **Wildlife – Assessment**

Request

Shell states that AEP's current IRP guideline requires surplus capability be managed for sport fish or livestock *(Vol. III, p. E16-9)*. Please clarify.

Response

The statement was made in error.

Question No. **5.15**

Shell No. **AEP 73**

Issue **Wildlife – Wildlife Health**

Request

73.1 This section contains a statement regarding the potential increase in mortality for displaced moose and suggests that, ultimately, mitigation is the responsibility of the regulators through appropriate adjustments to regulations *(Vol. III, p. E11-34)*. It has been identified that the Project will result in increased wildlife mortality due to displacement, increased access/hunting, and trapping pressure. Given current wildlife management practices involving large geographic areas, clarify how Shell views regulations as being effective for mitigation.

Response

73.1 Shell assumes responsibility for reducing indirect mortality to wildlife through phased habitat reclamation, and direct mortality through mitigation identified in the EIA.

Avenues that Shell understands are at the government's disposal for managing game and furbearer populations on large geographic scales include:

- changing bag limits for hunted species if data indicates populations are declining or sex ratios are skewed
- controlling access to reclaimed areas
- changing trapping quotas for furbearing species if data indicates populations are declining or sex ratios are skewed

Request

73.2 ER exceedances that are reported for many chemicals appear to be significant, but are reported to be marginal *(Vol. III, p. E11-75, Tables E11-10 and E11-11)*. Please explain when an exceedance is considered to be problematic. Provide additional information on how these chemicals can potentially manifest themselves in terms of wildlife health.

Response 73.2 A risk assessment has a lot of conservatism built into it at every stage. Therefore, a minor exceedance of 1.0 is not indicative of an adverse effect to wildlife. In the opinion of the risk assessors, ER values between 1 and 10 are clearly considered marginal. Examples of conservatism:

- benthic invertebrate tissue concentrations were used as a surrogate for pelagic invertebrate concentrations, but pelagic invertebrates would have much lower concentrations (water exposure versus sediment exposure)
- maximum concentrations used throughout
- 100% of diet from impacted areas every day of the year for their entire lifespan
- ERs for individual rather than population level effects

ER values for chemicals were less than 10. Therefore, no impacts to wildlife health are predicted.

Request 73.3 Molybdenum is identified as a potential concern in water for moose and bears in this section *(Vol. III, p. E11-62, Table E11-17)*. Shell further suggests that although molybdenum ER values are marginally exceeded for moose, it is not likely that such exposures would result in an adverse impact. Notwithstanding, please clarify potential mitigation should monitoring confirm that there is a concern.

Response 73.3 Although it is true that Volume 3, Part 1, E11-62 states molybdenum is a chemical of "potential" concern for moose and black bear, it is in the context of the preliminary and conservative chemical screening stage. The actual risk estimates computed in the follow-up detailed analysis indicate ER is less than 1 (i.e., inconsequential) for both species (see Volume 3, Part 1, Page E11-65 and E11-66). As no impacts were identified, mitigation is not required with respect to molybdenum.

Request 73.4 The vegetation sampling program was originally designed to examine the potential for uptake of contaminants into foods used by humans *(Vol. III, p. E-68)*. Discuss the appropriateness of using these food sources to study the effects on wildlife health. Indicate why more traditional wildlife food sources, such as browse species, berries, and forbes, were not used.

Response 73.4 These plant species are not necessarily the best to use for evaluating effects to wildlife. However, as stated in Volume 3, Part 1, Page E11-69, the vegetation-sampling program was originally designed to examine the potential for uptake of contaminants into foods consumed by humans. These data (berries, leaves and roots) were used as surrogates for chemical concentrations in other plant species used by wildlife, as this was the most current data available at the time of writing. Regardless, some wildlife species do consume these plants (e.g., bears eat blueberries, moose and mallards eat aquatic plants, such as cattails, and herbivores eat low bush leaves such as Labrador tea), and the evaluation does provide some insight into the potential for adverse effects to herbivorous wildlife. In addition, berries, leaves and roots were sampled to give an indication of chemical concentrations in different parts of plants that humans and wildlife might consume.

Question No. 5.16

Shell No. AEP 74

Issue **Wildlife – Wildlife Health**

Request

Table E11-12 describes susceptibility of KIRs to mortality during site clearing *(Vol. III, p. E11-82).* Please clarify how susceptibility to mortality for red-backed voles can be high all year, but low in the winter and spring. Other apparent inconsistencies and inaccuracies noted in this table should be corrected.

Response

See revised Table E11-12 in Attachment 5 at the end of this section.

Question No. 5.17

Shell No. AEP 75

Issue **Wildlife – Wildlife Health**

Request

Shell states that "the value of a Protection Plan is the advanced planning it represents; it is a commitment to be proactive. The Protection Plan acknowledges potential problems and identifies appropriate solutions and actions" *(Vol. III, p. E11-86).* Explain Shell's mitigation strategy to deal with the direct mortality of wildlife and describe, in general, Shell's proposed Protection Plan for wildlife, including plans for reducing wildlife road mortalities and monitoring wildlife mortality *(Vol. III, p. E11-85).*

Response

Such planning would be most appropriate at the detailed design phase. High speed roads will be designed for high visibility along the shoulders and ROWs. Shell will monitor wildlife road mortalities and wildlife-tailings interactions. Should high levels of traffic-related mortality be recorded for particular locations, mitigation in the form of signage, speed limits and fencing would be considered. Nuisance wildlife will be protected by means of strict garbage control and policies enforcing no feeding of wildlife (e.g., bears) and the use of beaver-proof culverts.

Question No. 5.18

Shell No. AEP 76

Issue **Wildlife – Monitoring**

Request

Changes in spatial patterns of vegetation communities are identified as a potential habitat impact *(Vol. III, p. E11-29)*. Shell discusses some mitigation measures such as "...pursuing progressive reclamation..." *(Vol. III, p. E11-47)*.

76.1 Please elaborate further on options for mitigating impacts from spatial alteration of habitat.

Response

76.1 Once key stakeholders and regulators have been consulted regarding preferred end land use options, the design of the reclamation plan will be finalized. Such planning is most appropriate at the detailed design phase. The landscape designs and wildlife habitats most suitable for the preferred wildlife species will be integrated into the reclamation layout. Guidelines for terrestrial wildlife landscape design are presented in the Oil Sands Vegetation Reclamation Committee Manual (1998).

Request

76.2 Discuss when and how wildlife health monitoring will be done *(Vol. III, p. E11-109)*.

Response

76.2 Conceptual monitoring programs have been identified throughout Shell's EIA, Shell's Project Update and in the questions and answers for various stakeholders. Once the approval for the Muskeg River Mine Project has been received, Shell will form an internal Monitoring Committee that will plan, design and implement the detailed monitoring programs for air, groundwater, surface water and wetlands, aquatic resources, reclamation, biodiversity, wildlife resources and wildlife and human health. In the planning phase, this committee will consider the regional monitoring programs that are currently operational, such as the Regional Aquatic Monitoring Program (RAMP), hydrology and climate, the Wood Buffalo Environmental Association (e.g., air quality and human health monitoring, terrestrial environmental effects monitoring), and complement these with "project-specific requirements" for the Muskeg River Mine Project. Several of these regional studies have components that relate to wildlife health issues, such as air and water quality monitoring, vegetation and soil studies. These will be augmented by additional wildlife health monitoring studies, as required, for the Muskeg River Mine Project. See also the response to AEP 35.

Question No. 5.19

Shell No. AEP 77

Issue **Wildlife – Monitoring**

Request

Shell indicates that the design for monitoring wildlife and biodiversity has not yet been established *(Vol. I, p. 16 – 48).*

77.1 Please clarify whether the program will include analysis and monitoring of restored Habitat Units (HUs) for identified KIR wildlife species to assess if reclamation progress is in line with wildlife habitat predictions to ensure that wildlife targets will be met.

Response

77.1 The detailed design of the wildlife monitoring program will be finalized after project approval has been obtained (see the response to AEP 35). The monitoring program to verify the achievement of wildlife habitat objectives will be undertaken as described in Section 6.2 of the Oil Sands Vegetation Reclamation Committee's report entitled *Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region.* The approach could include the following.

A combination of the coarse and fine-filter approaches could be used. At the coarse filter level, re-establishment of ecosite phase communities would be monitored to determine if the same types, abundance, sizes and distribution patterns of ecosite phases as existed in the predisturbance landscape are being reclaimed. Habitat requirements for most wildlife species would be met if a similar pattern of ecosite phases is re-established. In addition, preservation and reclamation of movement corridors could be monitored.

At the fine filter level, the biophysical variables thought to be important to the KIRs could be monitored in the reclaimed landscape. These variables are the same as those used in the HSI models (see Appendix 1 of the baseline report *Wildlife Habitat Suitability Indices [HSI] Modelling for the Muskeg River Mine Project).* HU calculations would be run using this monitoring data periodically to determine the success of KIR habitat reclamation.

Wildlife surveys (e.g., browse and pellet group counts, breeding bird surveys, aerial surveys, winter track counts) could also be conducted periodically to determine if species are making use of the reclaimed areas.

Request

77.2 Indicate if improvements to habitat identified will be adapted into successive reclamation.

Response

77.2 The monitoring program for wildlife habitat would include an adaptive feedback mechanism whereby, if the actual field measurements demonstrate that KIR habitat is not being effectively reclaimed, further refinement to the reclamation plans would be made.

Question No.	**6.1**	
Shell No.	**AEP 78**	
Issue	**Water – Hydrogeology**	

Request 78.1 Clarify whether Shell plans to provide progressively more accurate information on discharges and water levels in the coming years. A suitable 3-D mathematical model may be helpful in determining the groundwater status before, during and after mining operations and would allow better quantification of hydraulic activities. It also would allow integration of the effects from surrounding mining activities.

Response 78.1 Detailed mine engineering will require more specific characterization of hydraulic conditions in the immediate vicinity of the mine, to support detailed dewatering and depressurization system design. This information, along with data from the groundwater monitoring program, will be incorporated into new or revised groundwater models that will allow more accurate analysis than presently available.

Request 78.2 Please provide linkages between construction and mining activities and water balance (SW-2) and open water bodies (SW-5) for drainage diversion, aquifer depressurization, and muskeg dewatering *(Vol. III, p. E4-56 and E4-72)*. Will the drawn-down distance of the basal aquifer cause an adverse impact on remaining lakes, wetlands, and wet soils? As a similar approach on linkage was used for the CEA, the same comments apply to the evaluation of cumulative impacts. For example, it is indicated that the seepage from Kearl Lake alone could increase from 15 mm/yr to 63 mm/yr *(Vol. IV, p. F3-3)*. Clarify the resulting impacts on lake levels, lake ecosystems, surrounding wetlands, and down-stream systems.

Response 78.2 The linkages and impacts of drainage diversion and muskeg drainage/overburden dewatering are presented in the surface water sections including E4, F4, G4, E5, F5, G5, E6, F6 and G6. The effects of basal aquifer depressurization on water balance of nearby waterbodies are presented in Section E4.3. The cumulative effects of basal aquifer depressurization on the Kearl Lake water balance to both the CEA and RDR scenarios are presented in the response to DFO's questions (see the response to AEP 35).

Request 78.3 How does Shell determine dewatering levels of basal aquifer waters with an overall combined objective of minimizing the impact on the environment and safety of mining during the life of the Project?

Response 78.3 The basal aquifer will be depressurized by a well field to provide safe and efficient mining conditions at the base of the pit. Depressurization will occur ahead of mining. Wells will be located and spaced based on the hydrogeologic conditions so that the depressurized water level is below the base of the entire mining area, except at depressurizing wells, where the water level will be drawn to a maximum just above the pump inlet level. Shell's intention is to use the water produced in the extraction process, when practical, by storing it in the recycle water pond.

Request 78.4 Has the feasibility of re-injecting groundwater been evaluated? Please discuss options for rejection of mine depressurization water into abandoned mine areas.

Response 78.4 The feasibility of re-injecting the water was considered but has not yet been evaluated. The feasibility of re-injecting the groundwater would be possible only when the basal aquifer is sufficiently dewatered and could serve as a storage reservoir for the excess water. This condition would occur later in the project life, most likely after 10 years. Shell will investigate the re-injection option when appropriate.

Question No. **6.2**

Shell No. **AEP 79**

Issue **Water – Hydrogeology**

Request Question SWCEA-3 addresses cumulative impacts on open water areas including lakes and streams *(Vol. IV, p. F4-24)*. The evaluation indicates that post-reclamation surface water will increase relative to existing site conditions. Assess the relative ecological significance of these future water bodies with pre-development openwater bodies and wetlands.

Response Shell proposes a reclamation scenario that largely represents a shift from a predominantly wetlands environment to an upland environment. However, the mix of reclamation wetlands will include the end-pit lake, constructed wetlands (emulating a shallow, open water–marsh complex) and shrubby swamp as part of the drainage system. This reclamation scenario was developed to be consistent with the end land use objectives proposed by the Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan (IRP).

The ecological effects of these landscape changes are discussed in Sections E10 (wetlands), E16 (closure plan), E5 (water quality) and E6 (aquatic resources).

Question No. **6.3**

Shell No. **AEP 80**

Issue **Water – Hydrogeology**

Request The map on p. E10-6 shows wetlands crossing LSA boundaries that have not been included in the impact assessment *(Vol. III, p. E10-6)*. Shell indicates that wetlands were assessed to a point 1 to 2 km beyond the mine pit limit *(Vol. III, p. E10-6)*. Shell's rationale is that the influence of the surficial aquifer by mine dewatering activities will not extend beyond a 1 to 2 km distance. Please clarify why Shell believes that the effect of the drawdown will be limited to this distance.

Response The effect of dewatering on surficial aquifers is discussed in EIA Volume 3, Part 1, Section

E3.5.1, and also in Appendix IV. The drawdown in surficial aquifers adjacent to drainage ditches was evaluated using a 2-D finite element groundwater flow model. As shown in EIA Volume 3, Part 1, Figure E3-3, the effect of a ditch extends for a distance of 1 to 2 km, depending on the magnitude of natural groundwater recharge.

Question No. 6.4

Shell No. AEP 81

Issue Water – Hydrogeology

Request

Evidence suggests that there may be "hydrogeological windows" between the Methy and the basal aquifer. If they do exist, there may be large incursions of Methy brine into the basal aquifer through karst related features as the basal aquifer is being depressurized. This might be very difficult to control by grouting. Discuss how this may affect Shell's mining plans and any measures that Shell may take to control the flow and handle the increase in brine.

Response

See the response to DFO 46.

Question No. 6.5

Shell No. AEP 82

Issue Water – Hydrogeology

Request

Recent data compiled by the Alberta Geological Survey indicates that the subcrop of the McMurray Formation appears to extend beneath McClelland Lake. There may, therefore, be some seepage losses from McClelland Lake. According to distance-drawdown predictions given in Figure E3-4 (Vol. III, p.E3-13), if the basal aquifer is continuous and extends to McClelland Lake, dewatering at the Muskeg River mine would cause about 15 metres of head loss in the basal aquifer beneath the lake. Please provide an update of Shell's interpretation of this situation.

Response

If the McMurray Formation extends beneath McClelland Lake, seepage losses will be strongly influenced by the hydraulic conductivity of the material between the bottom of the lake and the top of the basal aquifer. Without knowing the thickness or hydraulic conductivity of this material, it is not possible to estimate seepage losses.

The Syncrude Aurora Mine EIA (Appendix D) considered a case of seepage from McClelland Lake into a depressurized basal aquifer. The seepage estimate in that document was 2.2 mm/a. A lake level and outflow monitoring station was installed on McClelland Lake by Syncrude in 1997 as part of the regulatory requirement for the Aurora Mine development. This program is ongoing in 1998.

Question No. 6.6

Shell No. AEP 83

Issue Water – Hydrogeology

Request

Boundary conditions used for the various groundwater flow models include a recharge flux applied to the upper model boundaries. This flux was applied to reclaimed parts of the land surface but not to natural surfaces. The natural recharge rate for the area ranges from 50 to 69 mm/yr, and is significantly greater than recharge fluxes used for most reclaimed surfaces (except surfaces consisting of tailings sand). This may not cause significant differences in groundwater flow configuration along cross-sections with only a small portion of natural surface. However, for cross-sections with a large portion of natural surface such as Sections 5-1, 3-1, 4-1 and the end pit lake (Vol. III, Appendix 4), such differences could be significant and result in different calculated seepage rates into or out of various pits. Explain why the application of recharge flux to natural surfaces is not appropriate or re-run the model with appropriate recharge fluxes applied to the entire upper boundaries.

Response

If a recharge flux is applied to the unmined portions of the cross-sections, the hydraulic head beneath the unmined land is higher than in the mine pits, and there is no outward seepage from the mine.

Given the uncertainty in groundwater recharge estimates, the approach used without groundwater recharge in the unmined land was considered to be more conservative, because it yielded the highest seepage rates out of the mine.

Question No. 6.7

Shell No. AEP 84

Issue Water – Hydrogeology

Request

The preferred source of process water is the Athabasca River near the barge landing (Vol. I, p. 8-17). An alternate source is the 75 metres of sand situated beneath Mills Island and Isadore's Lake. Figure 8-12 (Vol. I, p. 8-28) indicates that the Athabasca River alluvium extends beneath Isadore's Lake. Pumping from the sand is expected to induce infiltration from the Athabasca River through the alluvium but will also induce infiltration from Isadore's Lake. If the alternate source is chosen, how will pumping affect water levels in Isadore's Lake?

Response

There will be no effect on Isadore's Lake, as this alternative source of process water is no longer being considered (see Section 4.2, Water Management, in the Project Update).

Question No.	**6.8**
Shell No.	**AEP 85**
Issue	**Water - Water Quality and Quantity**

Request

Table E1-9 discusses impact description criteria for the Muskeg River Project *(Vol. III, p. E1-23, Table E1-9)*. Short-term duration for hydrogeology and groundwater is assigned to impacts of less than 2 years, however, effects from operations will occur over the life of the Project.

Please clarify why the duration "short-term" has been assigned in Table E9-11 *(Vol. III, p. E9-24, Table E9-11)*. Also indicate why a rating of "low frequency" has been assigned in this table, given that effects will be ongoing for the life of the Project.

Response

The key question relates to loss or alteration of wetlands, which includes both direct losses as a result of clearing and indirect losses relating to aquifer drawdown. The correct rating is low frequency for clearing and high frequency for aquifer drawdown.

Question No.	**6.9**
Shell No.	**AEP 86**
Issue	**Water - Water Quality and Quantity**

Request

Shell predicts increased percolation losses to Kearl Lake due to the capital project as representing 0.8 per cent of the total annual inflow *(Vol. III, p. E4-57)*. No estimate provided in the CEA or in the regional analysis to quantify potential impacts or interactions due to projects immediately adjacent to Kearl Lake (Aurora South, Shell Lease 13 East, Mobil Kearl) *(Vol. IV, Section F4.4.3)*. Please discuss.

Response

See the response to DFO 38.

The CEA did not include the assessment of potential changes in Kearl Lake, because the Muskeg River Mine Project will have no measurable effect on the lake water balance. As part of the response to DFO's questions, a detailed analysis for the CEA and RDR scenarios was conducted. The combined effects are conservatively estimated to be 2 mm drawdown in mean lake level and 2.5% reduction in mean lake outflow. These effects would be negligible to very low.

Question No.	**6.10**
Shell No.	**AEP 87**
Issue	**Water – Water Quality and Quantity**

Request 87.1 With regard to handling of large runoff events within the closed-circuit area, discuss whether these would be stored in the various ponds, or discharged to receiving streams *(Vol. III, p. E4-7).*

Response 87.1 The Muskeg River Mine Project will not release to receiving streams any water that will be in contact with the oil sands in the closed-circuit area. All mine area flood runoff will be stored in the closed-circuit area. The recycle pond and mine pit ponds will be used to store flood runoff volumes.

Request 87.2 According to the Water Management Plan, the system will be below minimum water requirements for the first 14 years.

- Could flood events be stored?
- What about future years when the water system has less excess capacity?

In general, indicate the conditions under which discharging to receiving streams would be considered.

Response 87.2 The river withdrawal rate for the first 14 years will be above (not below) the minimum withdrawal requirement. In years when the water system has less capacity, the following alternatives for minimizing the free-water will be considered:

- releasing groundwater to natural receiving streams if the water quality is acceptable
- treating and releasing CT porewater to receiving streams

In general, discharging to receiving streams would be considered if the water release did not cause negative impacts on water quality and fishery resources in the receiving streams.

Request 87.3 In the Project Terms of Reference (TOR), Shell is required to "discuss probable maximum flood and precipitation and influence on Project design and contingency plans". With the exception of the delineation of the Muskeg River 1:100 year flood plain, there is little discussion of extreme event handling. In the TOR cross reference, Shell lists Section E4-3 (which contains a discussion of Kearl Lake impacts), and Section E4-9, which does not appear to exist. Please clarify.

Response 87.3 There are errors in the cross-reference table for the surface water hydrology. The correct cross-reference sections should be E4.1.1 and E4.7. There is no Section E4.9.

The probable maximum precipitation (PMP) is presented in EIA Volume 2, Section D4. Design of the closure drainage systems included considerations of the probable maximum flood (PMF) as presented in the report *Feasibility Design of Reclamation Drainage Systems for the Muskeg River Mine Project.*

All water storage facilities in the mining area will be designed to handle the 100 year flood runoff event (see the response to AEP 87.2).

Extreme flood event handling will be included as part of the Emergency Response Plan that will be prepared for the commercial project before start-up.

Question No. **6.11**

Shell No. **AEP 88**

Issue **Water – Water Quality and Quantity**

Request

After 2022, there is a 25 per cent reduction in stream flow entering into Isadore's Lake *(Vol. III, p. E4-41, Table E4-15).* Clarify why it is reasonable to assume only a 1 per cent reduction in water depth *(Vol. III, p. E6-15).* Comment on the uncertainties or suitability of the existing environmental data to assess potential impacts to Isadore's Lake.

Response

An explanation is provided in EIA Volume 3, Part 1, Page E4-44.

The existing basin drainage area of Isadore's Lake is 27.3 km^2. This compares with the normal lake surface area of about 0.46 km^2. The basin area is about 59 times that of the lake surface area. The basin inflows far exceed net evaporation loss (lake evaporation - lake precipitation) and seepage loss at the lake. This indicates that lake outflows are frequent during runoff events.

Lake water level is a function of lake inflows, outflows and storage capacity. The relationship between lake inflows and lake water levels is nonlinear. Long-term daily water balance simulations were conducted based on the daily lake inflows, the lake storage-elevation curve, and the lake outflow rating curve. The simulation results were analyzed to derive the water level and water depth statistics presented in the EIA (e.g., Table E4-17). For the time snapshot in 2022, the average lake level will be reduced by 21 mm because of a 23% reduction in mean annual basin inflow to the lake. This compares with the existing mean lake water depth of 1.55 m. The reduction is about 1% of the mean water depth.

The available information provides a good basis for estimating the impacts on the Isadore's Lake water balance. However, Shell is committed to a future study to survey Isadore's Lake and its outlet channel (Page E4-56) to verify the hydrologic impacts estimated in the EIA. Potential impacts on the Isadore's Lake water balance will be monitored as discussed on page E4-55.

Question No. 6.12

Shell No. AEP 89

Issue **Water – Water Quality and Quantity**

Request

Describe the present water quality in the existing test pit and indicate where has, or where will, water from it go. Clarify whether the present water quality indicates potential end-pit lake conditions.

Response

Attachment 6 provides a data set for a sample from the test pit water taken near the surface on October 30, 1997. The water quality can be described as high in salts (1,156 mg/L TDS and 342 mg/L chloride), reflecting an historical influence of basal aquifer water as the test pit was filling. As the present head in the test pit is higher than the basal aquifer, there would be a net movement of test pit waters into the aquifer.

The test pit water will be used for pilot plant operation and subsequently in the project's full-scale operation.

Although the end-pit lake will be of a similar depth, the deeper portion closest to the basal aquifer would be filled with MFT, which is highly impermeable and known to have natural sealing properties. In addition, the test pit has no natural outflow and is more prone to increases in salt concentration than the end-pit lake which has natural inflow and outflows. Therefore, the test pit does not serve as an analogue to the end-pit lake.

Question No. 6.13

Shell No. AEP 90

Issue **Water – Water Quality and Quantity**

Request

With respect to the depressurization of groundwater, it is stated that the "high concentration of chlorides would prevent use as process water" *(Vol. I, p. 8-18)*. Clarify Shell's options, should this occur.

Response

Shell does not plan to use the basal aquifer as a sole source of process water. Water from the basal aquifer will be combined with make-up water from the Athabasca River and process recycle water from the tailings settling pond. Shell does not expect levels of chloride in the basal aquifer that would prevent its use, in conjunction with Athabasca River make-up and recycle water, as a source of process water. During operations, Shell plans to monitor the water chemistry of the process water and basal aquifer water. In the unlikely event that chloride levels of the basal aquifer were considered too high for its use as process water and other water quality parameters enable release to a receiving stream, Shell would apply to AEP for approval to discharge such water (with or without treatment as necessary).

Question No. 6.14

Shell No. AEP 91

Issue **Water – Water Quality and Quantity**

Request

Diversion ditches are proposed to divert surface waters away from and around the Project area, generally to the Muskeg River. Diversion ditches are cut into surficial materials, with consequent disturbance and exposure of material to erosion, which can lead to input of suspended solids (SS) (both inorganic and organic) to receiving waters.

Describe the expected impact of these ditches on this aspect, and on receiving water quality. Elaborate on Shell's intended mitigation to prevent impacts.

Response

Shell will use best management practices in constructing the diversion channels, including removal of all excavated materials from the channels. The surface drainage system consists of ditches and polishing ponds. Channel erosion rates in the diversion ditches are expected to be no greater than those in the natural channels. Therefore, no impact on water quality of receiving streams is expected.

The potential increases in TSS are summarized in EIA Volume 4, Table F4-8.

Question No. 6.15

Shell No. AEP 92

Issue **Water – Water Quality and Quantity**

Request

92.1 Shell states "Suncor's reclamation waters were selected to represent reclamation water associated with the Project" *(Vol. III, p. VII-4)*. Explain why only Suncor composite tailings (CT) waters were used here. Are Syncrude CT waters representative and should they be included?

Response

92.1 Suncor reclamation waters are generally thought to be more representative than those of Syncrude because Suncor uses less caustic in its process. The water quality (WQ) data used in assessments and modeling are compiled in Tables V-1 and V-2 *(Vol. III, p. V-7 and V-8)*. These tables list CT water quality and source it as from the June, 1996 report, *Hydrogeology Baseline Study, Aurora Mine*. However, that report does not appear to address CT water.

Request

92.2 Please indicate the data source for CT water quality. Clarify whether all the most recent data is used, and if not, whether this affects the assumptions and assessments.

Response

92.2 CT data in Tables V-1 and V-2 were mis-referenced. The intended reference was: Golder 1998: *1997 synthesis of environmental information on consolidated/composite tails (CT)*. Report for Suncor Energy Inc., Oil Sands, Fort McMurray, Alberta.

The data set used in the Steepbank and Aurora EIAs was used for the Muskeg River Mine Project EIA. These data still represent worst-case values, and ensure that water quality predictions described in the EIA are conservative.

Request

It is stated that "...porewater from CT disposal pits may migrate laterally from mine pits through groundwater in adjacent unmined areas, to the Muskeg River" *(Vol. III, p. E3-24).*

92.3 Quantify and explain the potential impact to the Muskeg River and associated aquatic ecosystems resulting from the potential contamination with CT porewater. Clarify the impact on terrestrial ecosystems.

Response

92.3 Placing CT deposits below grade minimizes lateral CT water seepage. The rate of lateral seepage was estimated to be 0.001 m^3/s, which is equivalent to 2%, 0.09% and 0.01% of the Muskeg River's 7Q10, mean ice and mean open water flows, respectively. As such, lateral CT seepage will be diluted at ratios of 50:1 and greater. Therefore, lateral CT seepage is not expected to have a significant effect on Muskeg River water quality. Similarly, as seepages are expected to be so limited, no effects are expected on terrestrial ecosystems.

Question No. **6.16**

Shell No. **AEP 93**

Issue **Water – Water Quality and Quantity**

Request

93.1 Appendix VII discusses IC_{50} values as the units used in assessments, but other sections in this appendix indicate IC_{25} is used *(Vol. VII, p. VII-5).* Please clarify.

Response

93.1 Acute toxicity units (TU_a) were based on LC_{50} test results while chronic toxicity units (TU_c) were based on IC_{25} values throughout the water quality assessment.

Request

93.2 This section notes that chronic toxic units were calculated with the IC_{25} values, as per the draft Environment Canada (1996) guidance document *(Vol. III, p. VII-5).* Such units were then used in modeling and the predicted toxic units compared to the surface water guidelines suggested in the AEP guideline protocol document. However, the TU_c guideline assumes that the toxic units were derived using the No Observable Effects Concentration (NOEC). Utilizing the IC_{25} would indicate less toxicity than utilizing the NOEC. Please clarify. Does this require recalculation of the values and model output?

Response

93.2 The IC_{25} endpoint has been ascertained by the US EPA (US EPA, 1991) to be the approximate analogue of the NOEC (i.e., the point at which there is no effect). It is also considered to be the preferred statistical method for determining the NOEC (US EPA, 1991). Using the IC_{25} does not mean less toxicity is being predicted. It means that a more accurate representation of toxicity is being predicted. Therefore a recalculation of the values is unnecessary.

Request

Presuming that IC_{25} values are to be used and the most sensitive of the test species is selected, data in Table VII-1 for fathead minnow growth in the Suncor Tar Island Dyke (TID) water gives IC_{25} of about 10 per cent, which is a TU_c of about 10, versus the value of 6.3 in Table VII-2 *(Vol. III, p. VII-6 and 7)*.

93.3 Please clarify. If the value should really be 10, do any of the other values require re-calculation? Discuss whether change is necessary to the predictions and assessments.

Response

93.3 In this case, the most sensitive value was not used. The value of 6.3 TUc was used to represent sand seepage and TID seepage from the tailings pond for all developments. The use of the 6.3 TU_c value for sand seepage represents a major difference in the sand seepage value employed for the Aurora EIA modeling, which was based on a single measurement from Syncrude's sand storage dump. The Aurora EIA value for sand seepage was several times less toxic than that employed in water quality modeling for the Muskeg River Mine Project EIA. Although this value was considered acceptable at that time, recent thinking suggested that a more conservative value could be employed (6.3 TU_c).

Employing the value of 6.3 TU_c rather than the more stringent fathead minnow value suggested is justified because:

- the Muskeg River Mine Project caustic-free extraction process is expected to produce tailings with lower naphthenic acid content, and hence toxicity
- earlier evidence suggests that sand seepage might be much less toxic than TID water (based on the Syncrude sand storage value)

The value used for TID seepage, which represented the value for sand seepage, was consistent with the value used for water quality modeling in the Steepbank and Aurora EIAs.

The TU_c value of 6.3 is an appropriate, worst-case value to use for representing sand seepage for the water quality assessment.

Re-running the water quality modeling for the Muskeg River with this more stringent chronic toxicity value (11.1 TU_c) results in an exceedance of the chronic toxicity guideline during 7Q10 conditions (1.2 TU_c, compared to the guideline value of 1.0 TU_c). This exceedance is projected into the far future for the CEA and RDR scenarios, similar to the situation that would have occurred if additional mitigation assumptions had not been employed for the Aurora mines initially.

The mitigative response that would likely be effective in reducing the predicted chronic toxicity value below guideline levels, is to increase the proportion of sand seepage water from the Aurora mines that receives aerobic as opposed to anaerobic degradation as the material travels to the Muskeg River. Employing this assumption (all sand seepage from Aurora mines) results in a chronic toxicity value of 0.7 TU_c. This reduction in toxicity can be accomplished by creating additional barriers (wetlands, ditches, perimeter cutoff plugs) between the reclaimed tailings settling ponds and the Muskeg River. Currently, we have assumed that a perimeter ditch intercepts half of the sand seepage flows from that source, similar to the Muskeg River Mine Project sand seepage flows. The seepage flow to the Muskeg River from the Muskeg River Mine Project reclaimed tailings pond is about one hundredth of the flow from the other developments. Therefore, although Shell is fully committed to mitigating this unlikely impact, additional mitigation by Shell would have little effect.

No toxicity problems are predicted for several decades and adequate time will be available to:

- assess whether such a chronic toxicity value could be representative of their sand seepage waters
- monitor groundwater between the operational tailings settling ponds and the Muskeg River
- explore available mitigative options that would ensure this potential impact is effectively mitigated with a self-sustaining system that is incorporated into the closure landscape

Because the TU_c resulting from the Muskeg River Mine Project alone is only 0.03 TU_c (compared to a guideline value of 1.0 TU_c), the model was not re-run with the more stringent toxicity value. Similarly, the model was not re-run for the Athabasca River as the current most stringent value is several orders of magnitude below the guideline.

Request 93.4 Consider the above comments on toxicity and reassess whether toxicity guidelines may be exceeded in receiving waters due to Project water releases. If so, what will be done to prevent this?

Response 93.4 Golder Associates believes that the approach taken in the EIA for predicting acute and chronic toxicity in receiving streams was a conservative and worst-case approach, particularly when it is recognized that the Shell process will likely yield lower toxicity as a result of the caustic-free extraction process. Although there is uncertainty associated with the toxicity values used, that uncertainty is adequately compensated through the numerous worst-case assumptions applied in the modeling. Section E5 (page E5-23) of the EIA outlines mitigative options for further remediating sand seepage waters from the Muskeg River Mine Project tailings pond.

Question No. **6.17**

Shell No. **AEP 94**

Issue **Water – Water Quality and Quantity**

Request Runoff water from the plant site adds up to a maximum of 7,563 acre-feet/yr. This amount will supplement the water withdrawn from the Athabasca River *(Vol. I, p. 8-18)*. Therefore, the maximum withdrawal from the river should be in the order of 70 Mm^3/yr (57,294 ac-ft/yr). Please clarify.

Response Table 5 of the *Water Management Plan for the Muskeg River Mine Project* presents the detailed water balance analysis, which accounts for runoff from the plant site, mine pit, and tailings settling pond dyke. This analysis shows that the maximum requirement for annual water withdrawal from Athabasca River is 5,950 m^3/h or 52 Mm^3/a based on average runoff conditions at the project area. The required licensed annual water withdrawal is 6,284 m^3/h or 55 Mm^3/a by aquifer depressurization and no inflow from mine and plant site runoff during a dry period.

Question No. 6.18

Shell No. AEP 95

Issue Water – Water Quality and Quantity

Request

The EIA report suggests polycyclic aromatic hydrocarbon (PAH) data for the Muskeg River is absent. Indicate whether Shell would participate in additional data collection for PAH effects. Shell should incorporate PAH sediment quality guidelines (Smith, S.L. et al, 1996) referenced on page E5-32 in the EIA assessment of operational and reclamation waters.

Response

Existing PAH data on Muskeg River water sediments is summarized in Tables D5-6 and D5-9. Shell is participating in RAMP, which will assess PAHs in surface waters in the oil sands area in greater detail than done to date, and has already committed to improvements to PAH monitoring under RAMP (i.e., inclusion of all relevant environmental media, use of ultra-low detection limits, additional sampling sites). Sediment quality guidelines will be used to assess existing sediment quality and potential effects of oil sands operations on sediment quality. For more details, see Section 7.2 (Monitoring and Research) in the Project Update.

Question No. 6.19

Shell No. AEP 96

Issue Water – Muskeg River

Request

With respect to the Muskeg River, please clarify the following

96.1 What are the existing concentrations of Ni and Mn *(Vol. II, Table D5-6)*?

Response

96.1 Existing nickel concentrations are 0.016 to <0.0004 mg/L (Ni concentration is included in the report *Shell Lease 13 Winter Aquatics Field Program).*

Existing manganese concentrations are 0.66 to 0.04 mg/L (Mn concentration is given in EIA Volume 3, Part 1, Sections E5-6 and E5-7).

Request

96.2 Existing mercury concentrations are presented in Tables F5-1 to F5-4 *(Vol. IV, p. F5-6 to 8)*. Why are existing concentrations for mercury stated to be 0.0001 mg/L when in fact, they are mostly non-detectable?

Response 96.2 The stated value is the median concentration taken directly from NAQUADAT Station 00AL07CC0500/550/600.

Request 96.3 Shell states that the "limited available data do not allow definitive conclusions regarding acidification of surface waters, suggesting that this issue should be examined further" *(Vol. IV, p. F5-18)*. Is there a plan to monitor pH depression in the Muskeg River to further assess this potential problem?

Response 96.3 See the response to AEP 33.

Request 96.4 Explain the implications of higher mean and low flows, especially for the cumulative effects assessment evaluation (CEA), on the Muskeg River aquatic ecosystem *(Vol. IV, p. F6-3)*. Elaborate on the potential impacts on spawning fish and survival of fry.

Response 96.4 The implications of flow changes in the Muskeg River are discussed in Section 7.1 (End-Pit Lake Discharge) in the Project Update.

Request 96.5 Explain flood damage risks and water contamination potential which may result from areas of the mine proposed to be located in the 10 and 100 year Muskeg River floodplains *(Vol. III, p. E4-10, Figure E4-5 and p. E4-17, Figure E4-12)*.

Response 96.5 All facilities located in the 10-year and 100-year flood risk limits will be protected against potential flood inundation and erosion failure during the flood events. The protection measures will include embankments and riprap, if required.

See the response to DFO 12.

Question No. **6.20**

Shell No. **AEP 97**

Issue **Water – Muskeg River**

Request Discharges from the end-pit lake due to transfer of mature fine tails (MFT) from the tailings pond in 2028-2030 will increase mean annual flows in the Muskeg River by approximately 1cms or 19 per cent *(Vol. III, p. E4-50)*. After this initial period, flows reduce to about 0.6cms, which are still about 15 per cent higher than the existing flow. Table E4-19 shows far future conditions of a 3 per cent increase in mean annual flow. Will the timing of discharges during the initial high-rate years correspond primarily to seasonal norms (e.g., correlating with or responding to natural runoff conditions), or will they be held relatively constant throughout the year? Indicate whether these large initial releases are expected to be relatively constant throughout the year, or whether there will be significant peaks and fluctuations in discharges to receiving water bodies.

Response EIA Volume 3, Part 1, Table E4-19, Note (f) states that a mean annual mature fine tailings

(MFT) transfer rate of 0.618 m^3/s was added to each future surface runoff discharge component at Node S1, S16, and S18 for the open-water season only. It was assumed in the EIA that MFT transfer would occur during the open-water season and would be held relatively constant during the release period. Its effects on the open-water flow conditions are presented in the same table.

End-pit lake water may also be discharged directly to the Athabasca River if it has the potential to unacceptably impact the Muskeg River. The temporary control measure will be in use until end-pit lake water quality has improved and can be released to the Muskeg River (see Section 7.1, End-Pit Lake Discharge, in the Project Update).

Question No. **6.21**

Shell No. **AEP 98**

Issue **Water - Muskeg River**

Request 98.1 Please indicate whether muskeg and overburden drainage will discharge to receiving waters in winter. Although the EIA report speculates that ditches will freeze up in winter, thereby preventing winter discharge, will this occur for the Alsands Drain and any other drainage ditches?

Response 98.1 It is assumed that muskeg drainage and overburden dewatering at the Muskeg River Mine Project area will discharge to the Muskeg River mainly in the open-water season (see EIA Volume 3, Part 1, Page E4-34). Because the overburden in the Muskeg River Mine Project area is less permeable than that in the Aurora Mine, it is not certain at this time if any muskeg drainage and overburden dewatering associated with the project will discharge to the river during the ice-cover season.

Request 98.2 There presently seems to be drainage from the Aurora site in winter. If winter drainage is probable, indicate how this affects the water quality assessment for the Muskeg River, which assumed no winter drainage.

Response 98.2 The water quality modeling for the CEA and RDR (EIA Volume 4, Sections F5 and G5, Key Question 1) indicates that, in 7Q10 flow conditions, reclamation waters from upstream operators represent most of the flow in the Muskeg River. Therefore, additional dewatering flows from the Muskeg River Mine Project would not produce different water quality results than those discussed in the EIA.

Question No. 6.22

Shell No. AEP 99

Issue Water - Muskeg River

Request

Figure E5-3 predicts temperature in the Muskeg River at node S16 *(Vol. III, p. E5-28)*. Section G5, Fig. G5-1 also predicts temperatures *(Vol. III, p. G5-11)*.

Is any warming or cooling of river flow assumed between the end pit lake outflow and S16? Indicate the implications for predicted temperatures between the end pit lake outflow and the downstream reaches of the Muskeg River.

Response

For modeling purposes, the end-pit lake outflow was considered to occur at Node 16. Therefore, no change was predicted to occur between the outlet of the end-pit lake and Node 16. This is a conservative assumption, which may be unrealistic, because end-pit lake water will travel to the Muskeg River via a channel over 2 km long. This assumption likely accounts for a large proportion of the cooling effect predicted in the Muskeg River and, thus, renders the analysis very conservative.

Question No. 6.23

Shell No. AEP 100

Issue Water - Muskeg River

Request

The technical report "Winter Aquatics field program" (Golder Dec 1997) noted that in March 1997, dissolved oxygen in the Muskeg River was lower than in Jackpine and Muskeg Creeks, and lower than the historical data. The cause appeared to be unclear.

100.1 Clarify what the general winter dissolved oxygen (DO) conditions are in the various reaches of the Muskeg River system.

Response

100.1 The report describing findings of the winter aquatics field program presents all available dissolved oxygen (DO) data for the Muskeg River basin (Table 3-1; Golder 1997). The data are summarized as follows:

Muskeg River – historical mean 8.7 mg/L and range in winter 5.7 to 11.2 mg/L. Golder (1997) measured 3.2 mg/L.

Jackpine Creek – historical winter measurement of 6.8 mg/L. Golder (1997) measured 10.3 mg/L.

Muskeg Creek – historical mean of 9.1 mg/L and winter range of 7.3 to 10.9 mg/L. Golder (1997) measured 10.5 mg/L.

Shelley Creek – Golder (1997) measured 3.7 mg/L in winter.

Mills Creek – Golder (1997) measured 10.8 mg/L in winter.

Isadore's Lake – Golder (1997) measured profile with DO range of 0.8 to 2.2 mg/L in winter.

Request 100.2 Is there any re-aeration through the lower reaches where stream gradient is higher?

Response 100.2 There are no data available to speculate on re-aeration of the Muskeg River in its lower reaches.

Request 100.3 Early work done under Alberta Oil Sand Environmental Research Program indicated oxygen deficits even in the open water season. Clarify the open water DO conditions and the main causes of DO depletion in the Muskeg River.

Response 100.3 Open-water dissolved oxygen concentrations in the Muskeg River Basin are provided in Attachment 7.

DO depletion in the Muskeg River is assumed to result from vegetative decay. However, the flow during winter months is derived from groundwater, which may also influence DO concentration.

Request 100.4 Elaborate on the effect of altered inflows from the Muskeg River mine area (drainage waters, end pit lake outflow), on depletion of DO. Indicate whether drainage waters will be released in winter. Since winter DO may not meet the Alberta Water Quality Guidelines (AWQG), there is no capacity to assimilate further biological oxygen demand (BOD). Discuss what will be done to prevent any increase in winter BOD load to the river.

Response 100.4 As indicated in the EIA for the Muskeg River Mine Project, no muskeg drainage waters are expected from the Muskeg River Mine Project mine in winter because of freezing of the shallow muskeg and overburden layers on site. Shell notes that other oil sands operators have been required by AEP to monitor DO and BOD from muskeg drainage sedimentation ponds and similarly expects such conditions on its operating approval.

In any case, properly designed sedimentation ponds are more effective at reducing sediment loads than the natural system. If oxygen levels are of concern as a result of the Muskeg River Mine Project, sedimentation ponds can be aerated.

Question No. 6.24

Shell No. AEP 101

Issue Water - Muskeg River

Request

The Regional Aquatics Monitoring Program (RAMP) proposal of March, 1997, indicates that water quality (WQ) will be monitored once a year and seasonally (except winter) every fifth year at two sites in the Muskeg River (*RAMP, Table 2.1*). Describe any enhancements to this monitoring that will be required to detect and manage any effects on the water quality of the Muskeg River system.

Response

Shell understands that AEP will be a participant in RAMP and can advise on appropriate monitoring. In addition, Shell has added additional monitoring sites for water quality on the Muskeg River (see Section 7.2, Monitoring and Research, in the Project Update).

Question No. 6.25

Shell No. AEP 102

Issue Water – Muskeg River

Request

102.1 Explain how conclusions regarding increased potential for erosion of the Muskeg River channel were determined, especially for the CEA evaluation *(Vol. IV, p. F4-2)*.

Response

102.1 The detailed methodology of impact analysis on increased erosion and sediment concentrations in the Muskeg River associated with increased river flows is presented in Sections E4.4 and E4.5. Similar methodology was used for the CEA and RDR.

Request

102.2 Explain how site specific erosion issues, with respect to increased flows, were addressed for stream features such as narrows or bends. Shell indicates that sedimentation will be minimal and channel erosion will only be 0.8 mm for the whole Muskeg River *(Vol. IV, p. F4-13)*. Clarify whether it is possible that there may be no impact in some areas, while major changes in channel morphology may occur in other areas. There will be an increase in low flows. Could this result in more bed load movement, especially during low flow periods? Discuss the effect on the river morphology, such as filling in pools faster and whether large amounts of silt might be expected to enter creeks during big rain events.

Response

102.2 River channel morphology is primarily affected by the river's mean and flood flow conditions. The low flow has negligible or minor effects on river channel morphology. The Muskeg River channel is in a natural regime of dynamic equilibrium.

Muskeg River channel bed material mainly consists of sands, and its bank material mainly consists of clay and silt. In natural conditions, the river has a small rate of bed load even during floods, because of the slow-moving water. The TSS plot in EIA Volume 2, Figure D4-20 shows this.

EIA Volume 4, Table F4-7, shows that the mean winter low flow will increase from 1.1 to 2.1 m^3/s for the worst case snapshot time in 2007. Based on EIA Volume 2, Figure D4-20, this will result in a very small increase in channel erosion rate. These winter low flows compare with the natural 10-year flood peak discharge of 68.7 m^3/s. Therefore, increased flows in the Muskeg River, including increased low, mean and flood flows, will have negligible effects on the channel erosion rates and, thus, on channel morphology.

It is expected that increased channel erosion associated with increased flows would affect the entire river reach downstream of the project. However, constricted reaches and outside river bends might experience slightly higher erosion rates than the other locations. If the average erosion rate will result in 1.2 mm depth of soil erosion for the RDR scenario for a 33-year period, the localized erosion is not expected to be higher than twice the average rate or 2.4 mm. This is still negligible.

Question No. **6.26**

Shell No. **AEP 103**

Issue **Water - Muskeg River**

Request

Discuss the implications of a pipeline spill, a chemical/petroleum tanker truck spill and a contaminated water pond containment structure failure on the Muskeg River *(Vol. III, p. E5-6, Table E5-2)*. Indicate the quantities and types of materials potentially involved. Describe the automatic controls and emergency response procedures designed to limit potential spill impacts. For the Project and on a cumulative development basis, please discuss the probability of spills that could adversely affect surface waterbodies.

Response

Volume 1, Section 16 details the types and quantities of materials involved with the Muskeg River Mine.

The likelihood of a pipeline or tanker truck spill is remote. However, depending on the time of year and on the material released, a spill could severely impact aquatic life in the lower reach of the Muskeg River.

The tailings structure will be designed and operated according to accepted provincial and federal regulatory and code standards. The probability of failure of this structure is remote. If such an improbable failure occurred, the effects on the Muskeg River would be catastrophic.

Accidental releases at the Muskeg River Mine will be prevented and controlled through best management practices, spill prevention procedures and emergency spill response planning. As part of their environmental management and emergency response procedures, Shell will:

- maintain an on-site spill response team with appropriate spill response equipment, including booms, pumps and other equipment currently in place at existing oil sands operations

- enter into mutual aid agreements with Suncor, Syncrude and the Regional Municipality of Wood Buffalo to increase the efficiency of spill containment and clean-up

- develop, in co-operation with the Regional Municipality of Wood Buffalo, a public consultation and information distribution system for keeping the public informed in the unlikely event of a spill

- establish a routine monitoring and maintenance program for all mine structures and equipment

- incorporate appropriate construction practices and engineered structures at river crossings to protect aquatic life and maintain existing water quality

More detailed descriptions of Shell's spill prevention and management plans will be provided as required by the provincial approvals process.

Suncor and Syncrude both maintain trained spill response personnel and equipment; they also have established emergency response plans and execute regular monitoring and maintenance of their respective mine structure and equipment. Shell will institute similar spill prevention and spill response programs. Given the pro-active approach of existing, approved and planned oil sands developments towards spill avoidance and rapid containment and clean-up, in the unlikely event that a spill occurred, it would have a limited effect on the aquatic environment.

Question No. **6.27**

Shell No. **AEP 104**

Issue **Water - Muskeg River**

Request The long term sustainability of the Muskeg River for fish production is discussed *(Vol. III, p. E6-2)*. Beginning with the Muskeg River Project, much of the Muskeg River watershed may be surface mined, however, watershed impacts are discounted by the inclusion of a no mining "buffer zone". Please substantiate the use of 100 meter buffer zones in protecting aquatic ecosystems and watershed integrity of the Muskeg River in the context of cumulative hydrogeological changes occurring from surface mining in this area.

Response The 100 m buffer zones along the Muskeg River are included to prevent direct impacts on the river from sediment and to protect the streambanks from erosion. The buffer size is consistent with the recommendations of the Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan (AEP 1996). Walters (1995) recommends buffer strips of 50 to 300 feet (i.e., less than 100 m).

The approach taken to maintain the long-term sustainability of the Muskeg River is to avoid direct physical alteration of the river itself, combined with maintenance of a suitable flow regime and the quality of the water in the river.

As these objectives have been met, the long-term sustainability of the productive capacity of the Muskeg River should be achieved. See Volume 3, Part 1, pages E4-7, E5-3, E6-9 for a summary of mitigations included in the project.

Question No. **6.28**

Shell No. **AEP 105**

Issue **Water – End-Pit Lake**

Request 105.1 Characterize "starting" water quality into the end pit lake. As the proposed constituents are added to the end-pit lake, describe its evolution during holding periods and predict conditions at the point when release to the Muskeg River is proposed. Indicate whether basal aquifers or water sands and the lake will create salinity problems for lake water quality. If so, discuss the mitigation approach Shell will use. Provide additional modeling information as required.

Response 105.1 Attachment 8 describes water quality conditions in the end-pit lake as it fills and begins to release to the Muskeg River. MFT placed at the bottom of the end-pit lake will act as a sealant, limiting the flow of saline groundwater into the lake. The predicted initial salt concentration is not high enough to significantly affect aquatic life. A relatively rapid decline in salt level is predicted during the first 20 years after filling of the end-pit lake.

Request 105.2 Describe the anticipated uses of the end pit lake. Is there any consideration of introducing fish into this lake? If so, discuss the potential problems that may exist regarding edibility, spawning and survival *(Vol. III, p. E5-36)*.

Response 105.2 As stated in EIA Volume 3, Part 1, page E5-35, "The intended end use for the lake is a self-sustaining, biologically productive waterbody." Although Shell is committed to meeting the expectations of stakeholders in developing the end-pit lake, it is expected that fish would be introduced to the lake at a point where they could colonize this waterbody. As this is an artificial waterbody, the physical features required by the various life stages of the target management species could be incorporated into the final configuration of this waterbody. As outlined in EIA Volume 3, Section E6.9.2 several characteristics of the lake would have to be considered if fish were introduced into the lake.

Request 105.3 Indicate how Shell will ensure that the end pit lake will be a valued component of the reclaimed landscape *(Vol. III, p. E16-16)*. Discuss potential values such as recreation, fisheries, and general wildlife habitat.

Response 105.3 The limnological characteristics that develop in the lake will be measured and from this information it will be determined what fish species are best-suited for introduction to the lake. The species ultimately introduced would be identified through stakeholder consultation.

See also the response to AEP 105.2.

The end-pit lake and surrounding wetlands will be designed to be suitable for wildlife, such as dabbling ducks, beavers and moose.

Recreational uses that would be preferred for the end-pit lake and the surrounding shoreline will be determined through stakeholder consultation. It is expected that consumptive uses would include hunting and fishing and that nonconsumptive uses could involve boating, picnicking and wildlife observation. The end-pit lake will be designed to meet these recreational preferences.

Question No. **6.29**

Shell No. **AEP 106**

Issue **Water – End-Pit Lake**

Request

With regards to the end pit lake water quality, please provide further clarification on the following:

106.1 potential for high levels of SS and turbidity due to the thin fine tails (TFT), tailings pond top water, and shoreline erosion

Response

106.1 Low turbidity is expected as a result of the project's caustic-free process. This will result in faster particle settling. The EIA notes that top water could be directed through reclamation landscape wetlands if improvement of water quality was desired before discharge into the end-pit lake. Shoreline erosion protection measures for the end-pit lake are presented in Section 4.5.3 of the report entitled *Feasibility Design of Reclamation Systems for the Muskeg River Mine Project.*

Request

106.2 oxygen conditions

Response

106.2 It is unlikely that a hypolimnion will become fully anoxic, and the epilimnion will remain well oxygenated throughout the year. The end-pit lake is expected to be oligotrophic-mesoeutrophic and the oxygen demand from the MFT and sediments will be low relative to natural lakes.

Request

106.3 basic ionic make-up

Response

106.3 Attachment 8 describes water quality conditions in the end-pit lake as it fills and begins to release to the Muskeg River. See the response to AEP 105.1.

Request

106.4 implications of the probably high sodium and sulphate concentrations. Are there any prairie lakes with similar ionic composition to provide an analogy? Although total salt concentrations may be below those known to limit plants *(Vol. III, p. E5-37)*, most lakes studied are not Na SO_4 types with similar total dissolved solids to the end pit lake.

Response 106.4 There are a number of sodium-magnesium sulphate lakes in Saskatchewan, surveyed by Hammer et al. (1975). Of the lakes surveyed by these authors, detailed biological data were collected in one lake with salinity in the range of 3.3 to 4.3 g/L (Wakaw Lake). This range in TDS is two to three times higher than the predicted maximum salt concentration in the end-pit lake (1.4 g/L). Wakaw Lake supported several species of submersed macrophytes ("large areas dominated by *Chara*", as well as *Ruppia*, three *Potamogeton* species, *Myriophyllum*, *Utricularia*, *Sagittaria*) in the littoral zone and emergent plants (*Scirpus*, *Phragmites*, *Typha*) around its periphery. Zooplankton (anostracans, cladocerans, copepods, rotifers) was abundant in most saline lakes surveyed by Hammer et al. (1975), and although detailed information is not provided, the benthic faunas of saline lakes were also productive, except for highly saline lakes (TDS>20 g/L). Several fish species were reported from lakes with salinity in the range of 4 to 7 g/L. Species diversity typically declined with increasing salinity for all trophic levels. However, the salinity of the end-pit lake is predicted to be below the lowest salt concentration in the lakes surveyed by Hammer et al (1975).

In addition, recent studies of natural, high sulphate wetlands (about 1500 mg/L sulphate, 400 mg/L sodium) by Suncor (unpublished data) in the oil sands area have reported moderate to high standing stocks of algae, plants and benthic invertebrates.

Overall, although high salinity has been reported to reduce diversity and inhibit biological production in surface waters, the elevated salt levels predicted in the end-pit lake after filling are not sufficiently high to prevent development of a productive ecosystem.

Request 106.5 potential for H_2S and ammonia generation in the EPL

Response 106.5 Because hydrogen sulphide is oxidized rapidly under aerobic conditions in aquatic systems, its concentration in most of the lake is expected to be very low, even if there was production of hydrogen sulphide in the bottom sediments. Therefore, sulphide is not expected to lead to any impacts on aquatic biota in the lakes. Elevated ammonia levels would similarly be remediated through oxidation.

Request 106.6 nutrient and algal conditions

Response 106.6 Nutrient and algal conditions in the end-pit lake are not expected to be different than those predicted for the Aurora end-pit lake. The end-pit lake is expected to be oligotrophic-mesoeutrophic.

Expected dissolved organic carbon levels might reduce algal biomass as a result of increased colour and reduced light penetration. There is some indication that this is the case in Kearl Lake, a natural lake in the region, as the median chlorophyll *a* level of 3 μg/L is lower than expected for a lake with a median total phosphorus level of 23 μg/L. (Based on Prepas and Trew's (1983) study, a chlorophyll *a* level of 8 μg/L would be expected for a typical lake in Alberta.) Hence, chlorophyll *a* level in the end-pit lake might be suppressed relative to other lakes in Alberta. A combination of modeling and laboratory studies will provide more detailed predictions of the conditions expected for the end-pit lake.

Request 106.7 planktonic and organic content of the outflow

Response 106.7 Planktonic and organic content of the outflow from the end-pit lake will be directly determined by nutrient and algal conditions discussed in the response to AEP 106.6. The reduced chlorophyll *a* level predicted previously (see the response to AEP 106.6), will likely be reflected in proportionally low planktonic and organic content in the outflow from the lake.

Request 106.8 monitoring of water quality

Response 106.8 Monitoring will be a function of the research and monitoring needs identified in EIA Volume 3, Part 1, Section E5.10.4, end land-use and other stakeholder committee recommendations as well as the expected regulatory requirements. Shell is a member of CONRAD, CETAG and RAMP and will become co-operatively involved with research associated with end-pit lakes.

Water quality and biological characteristics of the end-pit lake will be monitored during and after filling to follow the evolution of water quality and the development of biological communities. Monthly water sampling will be carried out during filling of the lake. This will be followed by seasonal sampling, after the rate of change in water chemistry has declined to a level that will allow reduction of monitoring frequency. Water quality parameter lists are anticipated to include all major classes of variables (conventional parameters, major ions, metals, organics, oil sands-related parameters, toxicity) and will be developed at the time of program implementation. Once the lake is filled, sediment quality and biological characteristics (plankton, benthic invertebrates) will also be monitored at the appropriate frequency.

Shell has also identified a monitoring program for the Muskeg River upstream and downstream from the end-pit lake discharge channel and within the channel, as noted in the response to AEP 101. Also see the response to AEP 35 regarding the Shell Monitoring Committee.

Question No. **6.30**

Shell No. **AEP 107**

Issue **Water – End Pit Lake**

Request Shell indicates it will be transferring MFT to the end pit lake *(Vol. III, p. E4-40).*

107.1 Discuss the potential impact to surface water quality.

Response 107.1 The potential impacts of transferring MFT to the end-pit lake are discussed in Sections E5 (Key Question WQ6) and E6 (Key Question AR5), of the EIA.

Request	107.2	Will fish from such a lake be safe for human or wildlife consumption?
Response	107.2	The EIA did not address the consumption of fish from the end-pit lake. Monitoring of end-pit lake water quality following closure will provide an understanding of the potential for uptake of contaminants into fish. This information will be used to determine when the lake should be stocked with fish.
Request	107.3	Describe any potential groundwater impacts due to MFT component seepage.
Response	107.3	The end-pit lake appears to be a groundwater recharge feature. It loses water vertically into the basal aquifer, and laterally into the reclaimed mine pits and into the unmined oil sands to the west of the end-pit lake.
Request	107.4	Discuss other alternatives for disposal of the MFT intended for the end pit lake, should impacts not be acceptable.
Response	107.4	If MFT transfer to the end-pit lake should prove unacceptable, MFT remaining after operations would have to be disposed of by alternate means, such as freeze and thaw.

Question No. **6.31**

Shell No. **AEP 108**

Issue **Water – End-Pit Lake**

Request	108.1	The long-term viability of the aquatic ecosystem in the end pit lake only considers habitat requirements and potential impacts to fish *(Vol. III, p. E6-40)*. Demonstrate how other wetland-related wildlife species are being incorporated into design considerations and assessment of potential impacts.
Response	108.1	Aquatic and semi-aquatic wildlife species, which commonly use these types of wetlands, such as dabbling ducks and muskrat, will make use of the end-pit lake wetlands. The littoral zone will be designed to be of adequate width and convolution to meet the needs of several wildlife species.
Request	108.2	"Aquatic resources monitoring will be done to confirm input predictions and to provide feedback on the effectiveness of mitigation measures" *(Vol. III, p. E6-42)*. Outline the contingencies if the Aquatic Resources Monitoring Program reveals unacceptable impacts.
Response	108.2	Shell is prepared to direct end-pit lake outflow to the Athabasca River, during the period of MFT transfer and highest release from the end-pit lake to ensure that aquatic resources in the Muskeg River are not negatively affected (see Section 7.2, Monitoring and Research, in the Project Update).

Question No. 6.32

Shell No. AEP 109

Issue Water – End-Pit Lake

Request

Describe the thermal structure of the end pit lake. With a depth of about 20 m of water overlying the MFT, and a narrow shape, wind action may be insufficient to mix the end pit lake. Clarify why the end pit lake is assumed to be fully mixed. Discuss the effect of stratification on water quality of the end pit lake, and consequently, on its outflow. Indicate the probability and implications of seasonal turnover of the water column, which might release the 'concentration of chemicals below the thermocline' (*Vol. III, p. E5-36).*

Response

Shell notes that the potential issue of a thermocline requires further study. The end-pit lake is expected to be thermally stratified at least some of the time during the summer months. Stratification is a feature common to all deep lakes in Alberta.

The fully-mixed assumption for modeling purposes might overestimate the quality of end-pit lake water during periods of stratification and conversely, might underestimate its quality during overturn periods. If future research identifies this as a potential problem, the option of enhancing the outlet point or the channel with wetlands would be examined, or redirecting the flow to the Athabasca River.

Question No. 6.33

Shell No. AEP 110

Issue Water – End Pit Lake

Request

110.1 Outline Shell's contingency for filling the end pit lake in the event the expected volumes of CT, MFT, TFT and free water do not materialize within the expected timeframes. Clarify whether the end pit lake be allowed to fill from surface runoff, or made up from Athabasca River withdrawals.

Response

110.1 If the end-pit lake is found to be filling too slowly, make-up water from the Athabasca River would be used, as discussed in EIA Volume 3, Part 1, Page E5-38. Surface runoff from reclaimed surfaces will be drained to the lake.

Request

110.2 Discuss whether the end pit lake is expected or designed to discharge year-round. Will the outlet be "maintenance-free" (e.g., no control structure) with the lake level designed to be self-maintaining? It is stated that the end pit lake would only produce a discharge flow in the open water season *(Vol. III, p. V-4)*, but *Vol. III, p. E4-48* indicates that at this node (S1), "mean ice-cover season flow will increase by

425%...". Please clarify. Are changes to the water quality assessment expected from this correction?

Response 110.2 For the Muskeg River Mine Project, an end-pit lake outlet structure will be provided to control flows, if required, during the management period. After this period, this temporary control structure would be removed if possible. The lake would then discharge year-round, albeit at a very low rate in the winter.

The MFT transfer will be suspended in winter. For the surface water hydrology component of the EIA, and as a hypothetical worst-case scenario, the end-pit lake is assumed to discharge only the seepage inflows and lake surface precipitation in winter. The mean ice-cover discharge for Node S1 is 0.012 m^3/s for the existing Alsands drain and 0.075 m^3/s for 2030 and the far future, which could increase the mean winter Muskeg River flow by 4% if released. This level of increase is small.

For the water quality component of the EIA, the end-pit lake is assumed to have no discharge in winter. The lake control structure can be used to achieve this no-release condition, if required.

In the far future, the end-pit lake will have an outlet channel, which will be maintenance free and sustainable, and will be similar to other natural lake outlet channels in the region. The EIA, including the surface water hydrology and water quality components, was conducted based on this project description.

Request 110.3 Annual end pit lake evaporation will exceed annual precipitation *(Vol. III, p. E4-47, Table E4-18).* At certain times of the year or certain years, will there be any outflow from the end pit lake?

Response 110.3 Lake inflows include runoff from reclaimed surfaces and lake surface precipitation. Lake outflows include lake release to the Muskeg River and lake surface evaporation. In the far future, the lake might not have any outflow for certain times of the year. Based on the 43-year simulation results for the period 1954 to 1996, the maximum duration with no lake outflow is 277 days. The probability of no lake outflow is about 11%.

Net evaporation (evaporation minus precipitation) loss will be compensated by basin runoff inflows. The ratio of the basin area to the end-pit lake surface area is between 4 and 5. This is similar to large regional lakes, such as McClelland Lake. This will ensure more sustainable lake outflows and minimize the risk of no lake outflows for a long time.

Request 110.4 After 2027, the Alsands drain becomes the outlet for the end pit lake with the mean annual discharge to increase 1560 per cent in 2030, reducing to a 123 per cent increase in the far future. Is the channel sized to handle these volumes of flow and major flood events?

Response 110.4 The end-pit lake outlet channel will use the existing Alsands Drain channel outlet, which will be re-designed for closure conditions. The required capacity of the new channel for closure is presented in Figure 13 in the report *Feasibility Design of Reclamation Drainage Systems for the Muskeg River Mine Project.* The new channel is designed to handle all flood flow conditions.

Question No. 6.34

Shell No. AEP 111

Issue Water – End Pit Lake

Request 111.1 In the water quality (WQ) modeling, it appears that the Suncor Tar Island Dyke (TID) drainage water quality was used as a surrogate for the TFT and tailings pond top water (that will be transferred to the EPL) *(Vol. III, p. V-7, Table V-1)*. Suncor TID drainage water has trickled through sand dykes and been mixed with percolating precipitation that falls on the dyke. Explain how this represents the future TFT and tailings pond top water.

Response 111.1 Suncor's TID water was used as a surrogate for thin fine tailings and tailings pond top water. This assumption was based on the fact that Suncor's TID has had a constant tailings input for an extended period, whereas the Muskeg River Mine Project's tailings settling pond would have been idle for four years before its volume would begin to be transferred to the end-pit lake. This idle pond would be subject to the same precipitation influence as the tailings pond bounded by TID. By the time of transfer, toxicity would have been reduced to some degree, likely below that of TID water. In addition, the Muskeg River Mine Project's caustic-free process will likely produce a less toxic tailings than those produced by current oil sands operations.

Request 111.2 TFT and tailings pond top water typically have high SS, with associated sorbed contaminants, that do not readily settle out. Discuss how this influences conditions in the end pit lake and the quality of its outflow. If these SS do not readily settle, how does this change the assessment for PAHs, which assumes settling *(Vol. III, p. E5-37)*?

Response 111.2 The water quality modeling does not assume settling of solids and associated PAHs. Nor does it assume resuspension of solids. As stated in the EIA, if top water requires additional bioremediation, it can be piped through the reclamation landscape wetlands before reaching the end-pit lake. Similarly, remediation of higher than desired solids concentrations could be achieved through channel outlet design features, such as enhancement with wetlands or a final sedimentation pond.

Request 111.3 Clarify why the predicted substance concentrations *(Vol. III, p. E5-36, Table E5-17)* are suggested to be the same as for the Aurora end pit lake, when the latter is not intended to have such large volumes of MFT, TFT, nor tailings pond top water placed in it.

Response 111.3 The statement was not clearly expressed and has been misinterpreted. They are the same substances, not the same concentrations.

Question No.	**6.35**	
Shell No.	**AEP 112**	
Issue	**Water – End-Pit Lake**	

Request 112.1 For all regional developments, factors such as end pit lake conditions, CT deposits, and water releases must be modeled and factored in . Indicate the assumptions that have been made for the water quality of other end pit lake outflows. Discuss the level of confidence associated with such projections.

Response 112.1 Shell has assumed that water quality from all end-pit lakes will be the same as that from the Muskeg River Mine Project end-pit lake. For RDR, end-pit lake flows from Shell East and Mobil Kearl Mine were assumed to be proportional to the size of the mine (barrels per day), and end-pit lake flows from Aurora North were identical to those in the Aurora EIA.

The conservative, worst-case assumptions used throughout the water quality assessment should ensure that variations in end-pit lake flows from other operations will not alter the overall predictions and conclusions described in the EIA. Therefore, the level of confidence in predicted water quality is moderate to high. However, as time progresses, Shell and other operators will have an increased understanding of the design and management options available to ensure that the water quality of the Muskeg River is protected.

Request 112.2 Section E5.10.5 discusses mitigation options if the end pit lake water quality turns out to be worse than predicted, such that water quality in the lake is unacceptable and the Muskeg River is jeopardized *(Vol. III, p. E5-38)*. Introduction of Athabasca River water is included as an option to supplement substance reductions. Does this mean dilution?

Response 112.2 Shell understands that there are many uncertainties associated with the end-pit lake, but believes that it can be designed and operated to achieve the desired end result of a viable, productive, self-sustaining lake with a non-toxic outflow at all times. The key to achieving this goal is proactive planning, research and monitoring. Shell is committed to participating with other regional operators and regulators to achieve this goal. This regional approach will be used not only to continually fine-tune design and operational parameters, but to assess the overall feasibility of the end-pit lake concept, so that a viable alternative is available for reclamation.

Shell is willing to participate in a multi-stakeholder committee to ensure that the knowledge gained on end-pit lakes over the ensuing decades is consistent with that required to ensure that they are viable reclamation features at closure.

The statement in the question ("option to supplement substance reductions") was intended to communicate that dilution afforded by Athabasca River water would supplement the natural decay processes.

Request 112.3 Provide Shell's views on the feasibility of active treatment of the outflow water. If nutrients were added to enhance productivity, would there be increased organic output to the Muskeg River with consequently higher oxygen demand?

Response 112.3 Managing the quality of the end-pit lake water so that it would be non-toxic by the time it has reached discharge level could be achieved by using Athabasca River make-up water at a sufficient rate to compensate for slower than predicted, conservative decay rates. The EIA has not identified the need for make-up water for the end-pit lake, but if make-up water was necessary, the initial outflow rate would be higher than predicted and the reclamation management period would have to be extended.

Request 112.4 If water quality takes a long time to improve, would the lake's holding capacity be exceeded and a discharge become necessary?

Response 112.4 Certain kinds of active treatment of the outflow could be undertaken if necessary. For example, if higher than desired suspended solids concentrations occurred, a sedimentation pond could be designed into the end-pit lake outflow channel to the Muskeg River. This settling pond could also be aerated if necessary. Additional passive treatment could involve enhancing the channel with wetlands.

No nutrient addition was identified in the EIA. The end-pit lake is not expected to discharge in the winter when the highest potential for oxygen depletion in the Muskeg River could occur. If nutrients were to be added during the reclamation management period to enhance productivity of the end-pit lake and the organic content in the outflow became of concern for the Muskeg River, a final polishing pond could be constructed in the outflow channel to settle vegetative matter or be used as an aeration pond.

Question No. **6.36**

Shell No. **AEP 113**

Issue **Water – End-Pit Lake**

Request The modeling for the end pit lake uses decay rates for toxicity (*Vol. III, p. V-11, Table V-4).* Indicate the basis for quantitative decay rates for toxicity (the cited Syncrude 1995 document is not provided in the references). Discuss the uncertainties that may exist with such rates. Indicate how such rates might vary in the proposed end pit lake and the consequences for resulting conditions and the impact assessment.

Response Toxicity decay rates were developed based on research conducted by M. MacKinnon at Syncrude's Mildred Lake Operation (pers. comm.).

There is uncertainty associated with the decay rates used. However, it is expected that the Shell caustic-free process will likely yield lower toxicity values than those used in the EIA, which would compensate for uncertainty in the decay rate.

If the decay rates in the end-pit lake are slower than assumed, MFT transfer rates can be reduced to increase retention times, and make-up water from the Athabasca River can be used to dilute end-pit lake waters and supplement natural decay. This impact would result in a longer reclamation management period.

Question No. 6.37

Shell No. AEP 114

Issue **Water – End Pit Lake**

Request

The Water Management Plan indicates initial rates of outflow are approximately 0.9 cms, or 23 per cent of mean annual flow of 3.9 cms *(Water Management Plan for the Muskeg River Mine Project, Golder, p. 35)*. Is this for the location where the outlet enters the Muskeg River? Shell has used 5.2 cms at station S16, downstream. An expected increase of 1.8 cms is stated for releases from closed-circuit operations *(p. 55)*. Clarify whether this is in addition to end pit lake releases. Mean annual outflow is expected to stabilize at 0.22cms (6 per cent), while Table E4-19 shows far future conditions increasing by 3 per cent *(Vol. III, p. E4-50, Table E4-19)*. Please clarify predicted outlet discharges for the end pit lake.

Response

The recorded natural flows at the WSC gauging station for the period from 1974 to 1995 were used for comparison with future conditions in the Water Management Plan report. The simulated natural flows for the period 1954 to 1996 were used in the EIA. The improved impact analysis presented in the EIA supersedes the preliminary impact analysis presented in the Water Management Plan report.

The mean annual discharge of Muskeg River is 3.9 m^3/s based on the short-term recorded data. The mean annual river discharge is 5.28 m^3/s based on the long-term simulation. The simulated value is believed to be more representative of the long-term conditions. The value of 0.9 m^3/s refers to the flow at the channel outlet entering Muskeg River. The value of 1.8 m^3/s refers to the total increase in the river flows. This includes the end-pit lake releases.

There is an error in the last sentence on page 35 of the Water Management Report. The sentence should be corrected as "The mean annual outflow from the end-pit lake is estimated to be 0.22 m^3/s in 2032." As presented on page E4-50 of the EIA, the end-pit lake outflow will stabilize at 0.1 m^3/s for the far future conditions.

Question No. 7.1

Shell No. AEP 115

Issue **Aquatic Resources**

Request

Shell is proposing to restrict access to the Muskeg River basin *(Vol. III, p. E6-38)*. Clarify how Shell will design buffers along the Muskeg River and incorporate public access.

Response

Because of safety concerns, Shell will not allow public access to development areas on its lease during project construction or operation. While Shell intends to post signs along the Muskeg River about mine activities, the public will be able to access the river at the mouth. Buffer strips along the river will be natural areas that are left undisturbed.

Question No. 7.2

Shell No. AEP 116

Issue **Aquatic Resources**

Request

An aquatic monitoring program is outlined *(Vol. III, p. E6-42)*. Indicate how Shell will monitor changes in the fish community and population, as well as changes in fish habitat, which may result from the Project. Clarify Shell's plans to monitor fish populations in spring and fall to determine effects, if any, of the Project on fish numbers *(Vol. III, p. E6-39)*. Please comment on the feasibility of continuing monitoring using a fish fence.

Response

Fish populations and fish habitat will be monitored as part of the RAMP. Shell expects that AEP will help guide the scope and development of RAMP.

Shell also plans to participate in the joint industry fish health studies with CT water. The results of fish population monitoring will be combined with fish health and toxicity data to provide a weight-of-evidence regarding the potential for effects on fish populations.

It is feasible to continue monitoring in the Muskeg River using a fish fence. When installed before important fish migrations (e.g., spawning, migration in the fall to overwintering areas), fish fences have provided reliable fish population data. Shell will consider using fish fences in spring and fall to monitor fish populations.

Question No. 7.3

Shell No. AEP 117

Issue **Aquatic Resources**

Request

Fish move out of the Muskeg River in the fall and over the winter *(Vol. III, p. E5-7 and E5-21)*. Is this connected to the increased level of certain compounds in the river during low flow periods? Is there any data available for the spring and summer months?

Response

Shell has not addressed the factors influencing existing fish distribution in the Muskeg River, as it is outside the Terms of Reference for the project. Fish movement out of tributaries to larger rivers is a common overwintering strategy for the fauna in this geographic region, and for areas that are not affected by oil sands.

Question No.	**7.4**
Shell No.	**AEP 118**
Issue	**Aquatic Resources**

Request CT pore water seepage may contaminate the basal aquifer *(Vol. III, p. E16-29).*

118.1 Provide Shell's assessment with respect to the implications if this occurs.

Response 118.1 Groundwater quality in the basal aquifer is not potable, because of naturally high levels of mineralization. Alsands basal aquifer sampling results (reported in *Hydrogeology Baseline Study Oil Sands Lease 13 Report*, Table 9B) show that most metals are in excess of water quality guidelines and are often higher than CT seepage quality. Therefore, an effect on the basal aquifer is unlikely.

Request 118.2 Will potable aquifer be affected?

Response 118.2 Groundwater within oil sands might or might not be of potable quality. However, even if it was potable, the hydraulic conductivity of this unit is too low to support exploitation of this resource. The surficial aquifers in the Quaternary sediments might be exploited for groundwater use. However, they have not been exploited in the past (with exceptions that would not be affected by the project).

Request 118.3 After closure, during flushes, is it possible that the retention time of CT waters may not be adequate to bioremediate the water? Discuss any impacts on when and how long it will take colonization of aquatic organisms to occur *(Vol. III, p. E16-32).*

Response 118.3 Because CT deposits will be below the surrounding ground level and will release water gradually (over several years), CT water volumes on the reclaimed surface and within the reclamation wetlands will be relatively small during any single storm event. High storm flows will also provide for considerable dilution of any CT waters carried off the reclaimed landscape and discharged into the end-pit lake. During storm events, retention times in the end-pit lake will remain in the order of months or years. For example, a sustained flood flow of over 2 m^3/s would be required to reduce end-pit lake retention times to less than 1 year, and 10 year flood flows were estimated at 0.7 m^3/s . Finally, water quality modeling for the EIA assumed that CT waters did not experience decay when travelling over the reclamation landscape to the end-pit lake. Therefore, storm events are not expected to affect water quality.

Shell acknowledges that continued monitoring and assessment of wetlands research is necessary to determine the impact on colonization time by aquatic organisms. See the response to AEP 35 regarding Shell's internal Monitoring Committee.

Question No. 7.5

Shell No. AEP 119

Issue Aquatic Resources

Request 119.1 Clarify why substance concentrations during open water are higher than for 7Q10 values for the Athabasca River, while the opposite occurs for the Muskeg River *(Vol. IV, p. F5-6).*

Response 119.1 The substance concentrations (mainly metals) are higher in the Athabasca River during mean open water flows because of the high sediment concentrations associated with that season. Many metals are in particulate form and not generally bioavailable, whereas low sediment loads occur in the winter, which suggests that associated metal concentrations would be lower (see EIA Volume 3, Part 1, Page E5-21). The sediment concentration is seasonally more constant in the Muskeg River under natural conditions. Hence, mine related flows have more influence at low flow when less dilution is available.

Request 119.2 Indicate the effect reduced temperatures will have on the Habitat Suitability Index during spawning time *(Vol. IV, p. F6-10).*

Response 119.2 Shell will monitor temperature in the Muskeg River and apply mitigation as necessary by restricting outflow from the end-pit lake during critical periods. Releases from the end-pit lake will be regulated to ensure that temperature changes will not negatively influence fish populations. For more details see Section 7.2, Monitoring and Research, in the Project Update.

Question No. 7.6

Shell No. AEP 120

Issue Aquatic Resources

Request Bioaccumulation of metals is not expected to occur as a result of this Project *(Vol. III, p. E6-36).* Will this be monitored as part of the Regional Aquatics Monitoring Program?

Response Monitoring of metals in fish tissue will be part of RAMP.

Question No.	**7.7**
Shell No.	**AEP 121**
Issue	**Aquatic Resources**

Request

121.1 Please discuss the affect the mine will have on flows, water depths and temperatures in the spring when spawning occurs (*Vol. IV, p. G6-5*). Shell has used "mean flows" in much of its analysis on water quality. Mean flows may indicate that nothing significantly different will occur, while daily and weekly fluctuations may have significant implications to the fishery. Clarify the implication to the Habitat Quality Index and whether this will also be true for April and May. Indicate whether water temperatures that will be depressed during the spawning period have potential to affect incubation time. Discuss the significance of any depressed temperatures. Please discuss the above in consideration of cumulative effects arising out of the Project and other approved or planned development in the area.

Response

121.1 The effects of changes in flow on fish KIR habitat suitability indexes are discussed in EIA Volume 3, Part 1, Pages E6-23 to E6-30. Low and mean flow conditions are evaluated. Specific monthly flows are not presented as the hydrograph presented in EIA Volume 3, Part 1, Page E6-16 (Figure E6-3) indicates that there is no change in seasonal patterns of flow. The hydrograph compares baseline conditions with the period of largest changes in flow from the project (year 2030). Hence, during other time periods, the differences in flow would be even smaller (see EIA Volume 4, Page G6-5).

To address concerns about changes in flow and temperature in the Muskeg River, Shell has provided supplemental information and a description of its mitigation and monitoring program for the Muskeg River (see Section 7.2, Monitoring and Research, in the Project Update).

Request

The discharges are not expected to exceed mean flows, but if flows are increasing and summer flows are staying about the same, yearly discharges will increase (*Vol. III, p. E4-69, Table E4-30*). This may have more impact than normal on this system (e.g., more bed load movement per year).

121.2 Please clarify the maximum and minimum flows in the Muskeg River. Clarify whether the duration/extent of the high and low flows are changed, (e.g., longer periods of high or low flows), especially during spawning period.

Response

121.2 No changes in the duration of high and low flows during the spawning period or at other times are expected as a result of the project (see Figure E6-3 on Page E6-16 in EIA, Volume 3, Part 1).

Question No.	**7.8**
Shell No.	**AEP 122**
Issue	**Aquatic Resources**

Request 122.1 Table E4-15 indicates that flows in the Muskeg River will not change appreciably *(Vol. III, p. E4-41)*. Up until the year 2010, the 7Q10 discharge will range from 33 to 45 per cent. Please discuss the impact this will have on the fishery and fish habitat.

Response 122.1 Table E4-15 is in the Surface Water Hydrology section in EIA Volume 3, Part 1. The potential impacts on fish and fish habitat are discussed in EIA Volume 3, Part 1, Section E6, Aquatic Resources.

Hydrological information relevant to the Aquatic Resources section is presented in EIA Volume 3, Part 1, Tables E6-4 to E6-7 (Pages E6-18 and E6-19). For analyses of the effects on fish and fish habitat, see EIA Volume 3, Part 1, Pages E6-23 to E6-32. The analyses include an examination of low and mean flows. The potential effects of flood flows are not discussed, as these flows do not differ between the baseline and the project.

Up until the year 2010, the 7Q10 discharge will range from 33 to 45% of baseline. The impact of these changes on fish and fish habitat is discussed on Pages E6-24 to E6-30.

Request 122.2 After closure, stream flows and open water 7Q10 discharges will increase by over 470 per cent *(Vol. III, p. E4-50, Table E4-19)*. Discuss any anticipated channel changes during this time period and potential implications for the fishery.

Response 122.2 No channel changes are anticipated after closure when open water 7Q10 discharges will increase by over 470%. River channel morphology is primarily affected by the river's mean and flood flow conditions. The TSS plot in EIA Volume 2, Figure D4-20 shows that the channel erosion rate is very low during low flow conditions. Even during floods, the river has a small rate of channel erosion.

Changes in flow in the Muskeg River after closure (during the end-pit lake management period) can be controlled by restricting the end-pit lake outflow. As discussed in Section 7.1 (End-Pit Lake Discharge) in the Project Update, the end-pit lake outflow will be controlled as necessary to prevent impacts on aquatic resources.

Question No. 7.9

Shell No. AEP 123

Issue Aquatic Resources

Request

Spring flows in the Muskeg River may be reduced in the closure plan *(Vol. III, p. E16-30).*

123.1 Please discuss impacts on the fishery and potential for reduced spawning habitat for pike. Clarify whether there will be a flushing of sediments from spawning areas prior to grayling migrating into spawn in the spring.

Response

123.1 The statement in the closure plan (EIA Volume 3, Part 1, Page E16-30) that spring flows in the Muskeg River may be decreased at closure is incorrect. Flows in the Muskeg River are slightly higher in the second year after closure (2030) and in the far future (EIA Volume 3, Part 1, Table E4-19, Page E4-50) for mean and low flows. Flood peaks are slightly lower (-1%) for far future conditions. The hydrograph shown in EIA Volume 3, Part 1, Page E6-16 (Figure E6-3) indicates that there is negligible difference in spring flows between baseline and 2030 flows.

As there is essentially no difference between baseline and post-closure flows, no potential effects on either northern pike spawning, or the frequency and duration of flushing flows are expected.

Request

123.2 Explain how post-reclamation drainage systems will be designed to optimize runoff residence time, sedimentation and passive water quality treatment *(Vol. III, p. E5-6, Table E5-2).* Clarify whether such features, which generally increase residence time in shallow surface water bodies, will adversely affect the temperature regime of the Muskeg River.

Response

123.2 The reclamation drainage system will largely consist of wetlands and the end-pit lake, which will allow settling of suspended sediments and warming of discharge waters due to enhanced retention. Detailed descriptions of these features are provided in Section E16 of the Muskeg River Mine Project EIA (Closure Plan). Assuming no retention, slight temperature declines were predicted in Section E5.7 of the EIA (Surface Water Quality). The increased retention pointed out in the question would allow warming of discharge waters, likely eliminating the slight cooling effect on the Muskeg River predicted in the EIA. There is also a large amount of standing water in poorly drained muskeg areas in the project area. Waters released from these areas are subject to warming because of naturally high residence time, suggesting that streams in the project area already receive warmer waters, relative to well-drained areas. Therefore, significant effects on water temperature are not expected in the Muskeg River.

To confirm impact predictions, Shell will monitor water temperature in the Muskeg River as part of RAMP.

Request

123.3 Significant changes in flow in the year 2030 are predicted, but impacts to the fishery does not appear to have been discussed *(Vol. III, p. E6-19, Table E6-6).* There will be changes in water depth and velocities. Please discuss. Since significant increased flows are expected during this period, describe the velocities during spawning period *(Vol. III, p. E6-25)*?

Response 123.3 Section 7.1 (End-Pit Lake Discharge) in the Project Update outlines Shell's modified approach for releasing end-pit lake waters to the Athabasca River instead of to the Muskeg River, during the years of maximum releases and during sensitive periods of spawning.

Question No. **7.10**

Shell No. **AEP 124**

Issue **Aquatic Resources**

Request 124.1 Open water 7Q10 discharges may be considerably higher than normal *(Vol. III, p. F4-10)*. Discuss the effect this will have in the amount of spawning substrate.

Response 124.1 Effects on the amount of spawning substrate from changes in flow in the Muskeg River are discussed on Page E6-27, paragraph 5, Page E6-28, paragraph 6, and E6-29 paragraph 5.

See AEP 121.1 for a response to the question about HSI during the 7Q10 period.

See also Section 7.1 (End-Pit Lake Discharge) in the Project Update for information on how Shell will mitigate impacts on fish habitat from flow changes.

Request 124.2 The Habitat Suitability Index was done during 7Q10 period of open water. Please clarify whether this was done during spawning, and if not, why not.

Response 124.2 The 7Q10 period for the open-water season would not likely ever occur during the spring. As the 7Q10 refers to the 7-day duration low flow with a 10-year return period, this would typically occur in the late summer or fall.

Question No. **8.1**

Shell No. **AEP 125**

Issue **Reclamation and Closure - Closure Planning and Landscape Design**

Request Shell states overburden and center reject disposal areas will be constructed in lifts to achieve 3:1 final slopes *(Vol. I, p. 4-25)*. This appears to be contradictory to Shell's desire to create landscapes, topography, and slopes in the reclaimed landscape that are similar to the predisturbance situation *(Vol. I, p. 10-17)*. Shell further indicates an intention to design and build all reclaimed surfaces with mature drainage networks with suitable drainage densities characteristic of the various types of natural landscapes *(Vol. III, p. E4-75)*.

125.1 Please describe what parameters identify a mature landscape.

Response 125.1 Mature landscapes can be defined as areas in which the rates of erosion are similar to those for other regional landscapes.

Request 125.2 Describe Shell's plan for final landform design of these disposal areas.

Response 125.2 With the exception of the reclaimed overburden disposal areas and the tailings settling pond area, all reclaimed landforms are comparable to pre-disturbance landforms (i.e., relatively flat).

Landform design is based first on ensuring geotechnical stability. Shell will use landform grading techniques, including micro topographical modifications, where practical. Shell will design reclamation drainage systems to evolve into mature watercourses. As with any reclamation system involving natural systems, the constructed system requires time to evolve to a mature system.

Request 125.3 Clarify whether Shell intends to use landform-grading techniques of micro and macro topographical features to create landforms with a natural appearance, and mature watercourses in the design of terrestrial structures and landscapes.

Response 125.3 Shell will construct techniques to ensure micro topographical features can be created with the final landforms.

Request Assessment of final landscape performance is discussed *(Vol. III, p. E16-4)*.

125.4 Describe landscape factors, capabilities and opportunities that will be created in the reclaimed landscape to replace those lost because of the development. Describe how Shell will ensure that landform designs are similar to the natural landscapes of the area and are aesthetically acceptable to the public.

Response 125.4 Shell has stated its reclamation and closure goals both in Volume 1, Section 16 and Volume 3. The reclamation and closure plan is designed around the development of ecosystems similar to those found throughout the region. The landforms created will include sloped areas, flatlands and aquatic areas, all of which are common in the region. Slope angles found on reclaimed areas will not be greater than those commonly found in the Athabasca escarpment areas. Therefore, Shell believes its reclaimed areas will be similar to regional natural areas and will be acceptable to the public.

Shell will also continue to work with regional committees established to define and refine reclamation guidelines and practices.

Request 125.5 Clarify what measures Shell will incorporate to prevent future recreational activities from negatively impacting reclaimed slopes and reclaimed vegetation.

Response 125.5 Shell will develop self-sustaining robust ecosystems on reclaimed areas. These areas, once mature, will provide a natural resistance to recreational activities similar to that of natural underdeveloped areas in the region. In addition, Shell will restrict access to all reclaimed areas until they have been certified by the AEP. Once certified, the land reverts to Crown control.

Question No. **8.2**

Shell No. **AEP 126**

Issue **Reclamation and Closure - Closure Planning and Landscape Design**

Request A map is included which describes the proposed reclamation drainage system at closure *(Vol. III, p. E4-18)*. The topography map provided is difficult to read.

126.1 Please provide 10 copies of 1:15,000 scale maps of pre- and post-disturbance topography for the Project area. Indicate the drainage channels that Shell intends to design into the reclaimed landscape.

Response 126.1 The requested maps are being provided to AEP under separate cover. Shell will provide copies of them to other stakeholders on request.

Request A number of watercourses are shown in the final reclamation layout *(Vol. I, p. 16-63)*.

126.2 Clarify whether diversion ditches could be designed as watercourses or riparian areas when installed that would survive to the closure landscape. Identify which watercourses have these potentials. Will drainage channels that become redundant and are not consumed by mine advance be reclaimed to their original conditions *(Vol. III, p. E4-16, Figure E4-11)*. With respect to the Surface Water Drainage and Diversion System maps, a number of ditches appear to disappear from map to map. Please clarify their fate.

Response 126.2 No diversion ditches will be used as part of the final reclamation drainage systems, because of the final landscape in both the Muskeg River Mine Project and the Aurora North Mine. All drainage ditches that become redundant and are not disturbed by mining operations will be reclaimed to natural conditions. There are errata on Figures I6-11 to I6-15. These diversion channels will drain to natural water courses shown on Figures E4-9 to E4-11. Diversion ditches that are not consumed by mining, and are not required by final closure planning, will be reclaimed.

Request 126.3 Provide a conceptual channel design that could be used for diversion ditches that have the potential to be riparian areas or watercourses in the closure landscape. Show how riparian areas could be incorporated into the design. Discuss the potential range of vegetation that would be suitable for these permanent riparian channel areas. Discuss opportunities to design these vegetation systems for enhancing wildlife habitat and travel corridors.

Response 126.3 The feasibility level design of the closure drainage systems, including typical drainage channel cross-sections, are presented in the report entitled *Feasibility Design of Reclamation Drainage Systems for the Muskeg River Mine Project*. Detailed vegetation reclamation design has not been conducted at this time. Species conducive to wetlands and riparian areas will be planted. It is expected that shrubby marsh vegetation (which is not defined as an ecosite phase) will be reclaimed along the channels. Consideration will be given to species used by wildlife (e.g., willow species for moose; sedges palatable to ducks). Tree and shrub cover will also be established along riparian channels so that wildlife movements will be enhanced. Wildlife habitat variables will be monitored over time after reclamation, to determine that the habitat for KIRs has been replaced.

Question No. **8.3**

Shell No. **AEP 127**

Issue **Reclamation and Closure - Closure Planning and Landscape Design**

Request Table E8-4 presents the areas of soil units in the closure landscape of the LSA. *(Vol. III, p. E8-17)*.

127.1 Clarify whether the 448 ha of Open Water in the reclaimed landscape represents the entire area of the end pit lake.

Response 127.1 The end-pit lake comprises 448 ha of open water in the reclaimed landscape.

Request 127.2 In addition to the end pit lake, what is the projected area of wetlands in the reclaimed land use plan?

Response 127.2 Wetland areas are discussed in subsection E16.4.2 - Reclamation Units with particular reference to Table E16-1: Areas of Constructed Ponds and Wetlands. Within the development area there are 207 ha of constructed wetlands and an additional 94 ha of ponds, excluding the end-pit lake.

Request 127.3 Please provide an estimate of CT wetlands areas versus non-CT wetland areas in the reclaimed landscape.

Response 127.3 Subsection E16.6.6 - Wetlands on CT Deposits indicates that CT water will flow through all of the wetlands in the reclaimed landscape.

Question No.	**8.4**
Shell No.	**AEP 128**
Issue	**Reclamation and Closure - Closure Planning and Landscape Design**

Request

Reclamation closure planning is discussed in this section *(Vol. III, p. E16-3).* The Oil Sand End Land Use Committee recommendation 2.1 suggests that reclaimed landscapes should have continuity of landform and watershed systems across lease boundaries. Provide a mine closure plan which discusses the opportunities, techniques and management principles that will be used to integrate closure planning with Syncrude's Aurora North Mine, and the area surrounding the Muskeg River Project.

Response

EIA Volume 3, Part 1, Section E16 (Closure Plan) outlines the terms of reference, objectives, planning approach and other relevant details on the closure landscape. Subsection E16.6.14 (Compatibility with Nearby Developments), specifically Figure E16-6, discusses the planned integration with the Aurora North Mine. This is expected to be an iterative process that will be refined, and revised if necessary, as a result of ongoing consultation between the proponents as the two developments progress.

Shell has not specifically integrated the closure plans for the Muskeg River Mine and the Aurora North Mine as part of the application. Shell is party to a cooperation agreement (see application) with Syncrude which addresses this. Shell will continue to explore opportunities for coordinating mining and reclamation operation near lease boundaries.

Question No.	**8.5**
Shell No.	**AEP 129**
Issue	**Reclamation and Closure - Closure Planning and Landscape Design**

Request

As part of its discussion on performance assessment, Shell suggests that shallow skin failures typically have a low consequence of failure and can be repaired by regular maintenance *(Vol. III, p. E16-21).* Please clarify the duration of maintenance needed on tailings pond slopes.

Response

The maintenance and repair of the shallow skin will be continued until the operations have been curtailed and the tailings settling pond has been emptied.

Question No. 8.6

Shell No. AEP 130

Issue **Reclamation and Closure - Closure Planning and Landscape Design**

Request Clarify whether the re-established groundwater table in the near and far future, will allow for reclamation to upland terrestrial ecosystems on CT deposits. Describe the measures that Shell will conduct to determine the optional level of groundwater table for reclamation.

Response The equilibrium depth to water table in the reclaimed landscape will be a function of landscape geometry, soil, climate, and surface and subsurface drainage features. These factors will be engineered in the design of the reclaimed landscape to help achieve the required water table depth.

Question No. 8.7

Shell No. AEP 131

Issue **Reclamation and Closure - Closure Planning and Landscape Design**

Request In a discussion on self-sustaining ecosystems and activity, Shell uses the term "...minimal and reasonable measure of management..." as a criterion for achieving these ecosystems *(Vol. III, p. E16-37)*. Please clarify what Shell means by the statement.

Response It is expected that a routine level of reclamation management will be required, such as that currently experienced for reclaimed areas within the region (e.g., roadway allowances).

Question No. 8.8

Shell No. AEP 132

Issue **Reclamation and Closure - Closure Planning and Landscape Design**

Request Table G7-3 provides a residual impact summary for macroterrain units and rates frequency as "low" *(Vol. IV, p. G7-5)*, whereas Table F7-3 rates the frequency as "long-term" *(Vol. IV, p. F7-7)*. Explain the difference between the two scenarios and clarify why the frequencies differ.

Response The frequency should be low for both F7 and G7 because the disturbance will only occur once.

Question No. 8.9

Shell No. AEP 133

Issue **Reclamation and Closure - Biodiversity**

Request

Shell states that reclamation will re-establish a variety of reclaimed landscapes and provide the basis for a functionally diverse reclaimed landscape *(Vol. I, p. 10-17)*. Shell intends to use a muskeg soil mix applied at 20 cm across the range of landscape structures to create a Class 3 soil (*Vol. 1, p. 16-40*).

133.1 Will a uniform application of such soils detract from Shell's ability to recreate a diverse landscape? Please demonstrate, by ecosite phase and species, that these landscapes are sustainable in the medium to long-term period and will be able to regenerate on this medium. Describe the research Shell will conduct to demonstrate that sustainable ecosystems are achievable.

Response

133.1 Shell followed the guidelines detailed in the *Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region* to determine the ecosite phases for the reclaimed landforms. Landscape diversity is not solely a function of soil cover but the interaction among soil, landform composition, slope, aspect and climate. The guidelines consider these factors in setting out the ecosite phases and species composition for designated reclamation locations. Shell will continue to participate and seek guidance from the Oil Sands Vegetation Reclamation Committee.

Suncor and Syncrude currently monitor the progress of plant species, soils and vegetation community re-establishment on reclamation plots. Several years of monitoring are required to verify the medium and long-term sustainability of the landscape. Similarly, Shell will establish research test plots to monitor when targeted plant species, soils and vegetation communities re-establish on reclamation soils. See the response to AEP 35 on Shell's Monitoring Committee.

Request

133.2 Describe the research necessary to substantiate that the site index productivity of the reclaimed landscape will meet pre-disturbance levels *(Vol. III, p. E9-39)*.

Response

133.2 Shell will establish monitoring test plots on reclaimed sites to determine if targeted site indices will re-establish on reclamation soils.

Request

Table 16-15 lists plant species that Shell plans to establish in the reclaimed landscape *(Vol. I, p. 16-46)*.

133.3 Given that only one type of soil is proposed for reclamation, outline proposed research to substantiate that these species can be successfully introduced. Clarify the type of soils and moisture regimes these plants normally inhabit.

Response

133.3 See the response to AEP 133.1. The soil and moisture regimes for these plants are listed in Table 16-25 (Vol. I, p.16-46).

Request 133.4 Shell indicates that diversity of reclaimed plant communities will be established over time beginning with the use of "starter species" (*Vol. III, p. E9-36).* Since the soils and parent materials in the reclaimed landscape will not be similar to that found in respective natural ecosites, indicate how Shell intends to determine whether the proposed ecosite phases are sustainable and that equivalent capability is established.

Response 133.4 Shell followed the guidelines detailed in the *Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region* to determine the ecosite phases for the reclaimed landforms. Shell will continue to participate and seek guidance from the Oil Sands Vegetation Reclamation Committee and other oil sands operators.

Request 133.5 Shell states that "Adaptive reclamation management will facilitate and respond to the vegetation process to meet specific land capability objectives" *(Vol. I, p. 16-45).* Discuss Shell's intention to conduct research to substantiate various methods for establishing diversity of vegetation types.

Response 133.5 See the response to AEP 133.1.

Question No. **8.10**

Shell No. **AEP 134**

Issue **Reclamation and Closure – Biodiversity**

Request Shell indicates that it is not possible to provide a comparison of pre- and post-development biodiversity *(Vol. III, p. E16-36).* Clarify how this was accomplished for the Ecological Land Classifications (ELC) vegetation and wetland predictions. Please outline the biotic and abiotic diversity factors that will demonstrate the level of potential biodiversity in the pre-disturbance and reclaimed landscape.

Response See the responses to AEP 57 and 58.

Question No. **8.11**

Shell No. **AEP 135**

Issue **Reclamation and Closure - Biodiversity**

Request 135.1 Clarify whether reclamation will be targeted at creating similar to predisturbed levels of biodiversity. Indicate how reclamation will be conducted to take advantage of opportunities to add diversity of topography, soils and vegetation. Please provide a management plan, process and schedule for creation of a biodiverse reclaimed landscape.

Response 135.1 Current reclamation targets are for equivalent land capability. Reclamation practices are designed to establish the potential to achieve pre-disturbance biodiversity levels for upland communities.

However, where possible, emphasis to improve topography, soils, vegetation and patch size diversity during the reclamation process will be undertaken. In Shell's detailed reclamation planning, we will follow the guidelines recommended by the Oil Sands Vegetation and Wetlands Reclamation Committees.

A detailed management plan, process and schedule for monitoring biodiversity on the reclaimed landscapes has not been developed. However, Shell will follow the recommendations detailed in the Ecological Diversity Monitoring (Appendix E) of the *Guidelines for Reclamation to Forest Vegetation* (1998) prepared by the Oil Sands Vegetation Reclamation Committee to determine the appropriate management plan, schedule and process.

Request 135.2 Figure 16-16 displays the final ecological land classification following reclamation *(Vol. I, p. 16-63)*. Please clarify whether the polygons shown in Figure 16-16 are the final range of ecosite diversity or whether there is a further breakdown of ecosite phases within those polygons. Indicate the management principles that will guide Shell's establishment of ecosite vegetation types and their distribution across the landscape.

Response 135.2 Figure 16-16 represents the vegetation communities for the final landscapes based on the recommendations described in the *Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region.*

Although the final vegetation communities will be less diverse during the initial stages of reclamation, it is expected that variability in ecosite phases will increase with vegetation succession in the reclaimed landscapes. Progressive reclamation over the life-span of the mine will also allow for multi-aged stands to re-establish on the reclaimed landscape. In the far future, it is expected that vegetation diversity will increase.

Shell will follow the management principles that have been established by the existing oil sands operators for various end land use options, some of which have been documented in the *Oil Sands Vegetation Reclamation Committee Manual* (1998).

Question No.	**8.12**
Shell No.	**AEP 136**
Issue	**Reclamation and Closure – Revegetation**

Request

Shell indicates that it intends to establish native ecosystems in a speedy and progressive manner *(Vol. I, p. 16-38).*

136.1 Clarify if the seed mixes for infrastructure areas are also proposed for revegetation of overburden disposal areas or tailings settling ponds *(Table 16-11).*

Response

136.1 Shell intends to use an annual nurse crop in its reclamation program to control erosion while native species colonize the areas.

Request

136.2 Indicate whether the species used will spread from established locations and permit the invasion of native species. Clarify how long this would be expected to take.

Response

136.2 Experience with reclamation on oil sands sites has shown that agronomic grass seed mixes slow the invasion of native species as well as the growth of planted woody-stemmed species. Therefore, seed mixtures will typically not be used on overburden or tailings sand areas. Occasional use for erosion control purposes might be made of a native seed mixture.

Request

Shell indicates an intention to use native plants whenever possible *(Vol. III, p. E11-97).*

136.3 In what instances would Shell use non-native plants? What species would be used? The use of non-native plants may remove the opportunity for reestablishment of native ecosystems as previously indicated. Please comment.

Response

136.3 Shell intends to use an annual nurse crop in its reclamation program of overburden disposal areas and tailings sand slopes. If erosion problems develop, Shell will seed small problem areas with a native seed mixture. As stated in the response to AEP 136.2, Shell is willing to adjust the composition of the seed mixes.

Request

Monitoring programs are described *(Vol. III, p. E9-39).*

136.4 Please clarify why Shell uses the term the establishment of benchmark "reclamation" plant communities rather than the establishment of benchmark "native" plant communities. Discuss the establishment of control benchmark native communities in offsite undisturbed native ecosystems, and how they will serve as surrogate targets for the reclamation ecosites.

Response

136.4 Control plots will be established following standard scientific protocols. Monitoring programs will be consistent with recommendations from the Oil Sands Vegetation and Wetlands Reclamation Committees. This will include the establishment of control benchmark native communities in undisturbed ecosystems.

Request Shell proposes to broadcast seed at 25 kg/ha on pipeline rights of way in hydric forests, bogs and fens *(Vol. I, p. 16-39)*.

136.5 Clarify whether soil erosion would be an issue on areas of organic soils. How will the use of these seed species contribute to the establishment of native ecosites? Confirm that Shell intends to use the Land and Forest Service document, *Recommended Native Grasses and Legumes for Reclamation in the Green Area* (1996).

Response 136.5 The seeding of pipeline rights-of-way is standard industry practice.

Soil erosion of organic soils is not predicted to be an issue. Native grasses and legumes, as outlined in the Land and Forest Service document, *Recommended Native Grasses and Legumes for Reclamation in the Green Area*, will be used for part of the broadcast seed mixture. It is expected that native species from adjacent ecosites will colonize pipeline rights-of-way over time. Shell intends to use the Land and Forest Service document, *Recommended Native Grasses and Legumes for Reclamation in the Green Area* (1996).

Request 136.6 Please comment on the requirement for maintenance fertilizer, the proposed rate of application, particularly nitrogen addition and its effect on the establishment of native plant species *(Vol. I, p. 16-45)*.

Response 136.6 Shell will develop its maintenance fertilizer program based on the data collected on soil nutrients and ground cover density and composition. Shell is participating in the Oil Sands Vegetation Reclamation Committee and will follow its guidelines and recommendations based on existing oil sands operators.

Question No. **8.13**

Shell No. **AEP 137**

Issue **Reclamation and Closure – Revegetation**

Request Shell has outlined a method of increasing the rate of colonization by using ecosystem implants *(Vol. I, p. 16-46)*.

Please provide more detail on Shell's intended use of this method for revegetation of reclaimed lands. Indicate the ecosites, percentage of the landbase, and relative importance of the landbase for which Shell intends to use this method.

Response Shell will assess the cost-benefit of using ecosystem transplants early in the phased reclamation scenario. Its scale of use will be determined based on the early assessment programs.

Question No. 8.14

Shell No. AEP 138

Issue **Reclamation and Closure – Revegetation**

Request

Table 16-15 shows a range of vegetation possible for each ecosite phase *(Vol. I, p. 16-46)*. What approach will be used for species selection within ecosites? Will there be a combination of pure species types and mixedwood types?

Response

The table, Planting Prescription by Ecosite Phase, was adapted from the draft *Guidelines for Reclamation to Terrestrial Vegetation in the Alberta Oil Sands Region* produced by the Oil Sands Vegetation Reclamation Committee. The committee has recognized that some plants are not proven for reclamation propagation.

Shell will work with other operators and stakeholders on studies to assess appropriate reclamation species. Shell's planting prescription will follow the guidelines.

Question No. 8.15

Shell No. AEP 139

Issue **Reclamation and Closure - Land Use**

Request

In this section, Shell discusses a number of significant gravel deposits that occur in the Project area *(Vol. I, p. 2-6)*.

139.1 Please describe the quantity and quality of aggregate within the development area.

Response

139.1 The major documented granular resource in the project area is the Susan Lake gravel deposit. (It should more logically be termed the Ridge A deposit, after work in the Alsands era.) Within the bounds of Lease 13, the deposit is located in the western halves of Sections 29 and 32, and the eastern halves of Sections 30 and 31 of T95N, R10W. This deposit is a surficial deposit and the site of a present quarry.

This deposit (within the confines of the Lease 13 project area) has geologically (in situ) proven resources of about 23 million m^3 of aggregate material. The approximate breakdown of the material is 45% coarse aggregate and 55% fine aggregate. Coarse aggregate consists of all gravel-size material, while fine aggregate consists of all sand-size material plus any fines present in the sands. It is estimated to contain 85% durable rock types and 15% potentially poor or deleterious rock types. It is expected to be suitable for most construction uses, including concrete aggregate, engineering backfill, road construction, and several other miscellaneous applications.

In general, most areas of Lease 13 have been well searched for significant granular resources by photo-interpretation and field mapping methods, as well as overburden drilling and geophysical conductivity profiling.

Other less well known, or speculative, deposits exist within Lease 13. These include the Muskeg River deposit, and several other unnamed deposits of lesser known quality and quantity. Some of these are buried, water-saturated deposits, with little suitability testing data available for comparison with standards or other deposits.

Request 139.2 Clarify how aggregate resources within the development area will be managed, royalties paid, and if appropriate, made available to the public or industry.

Response 139.2 Aggregate resources within the Shell development area will be managed by Shell in coordination with the various lease holders where Shell is the holder of the rights to the aggregate. Royalties will be paid by Shell. Aggregate resources will be made available to the public or industry at Shell's discretion.

Question No. **8.16**

Shell No. **AEP 140**

Issue **Reclamation and Closure - Land Use**

Request

Traditional Aboriginal foods and medicines are ranked in order of use *(Vol. III, p. E15-3, Table E15-1)*. Table E14-1 (*Vol. III, p. E14-3*) references a number of berry-producing species important to aboriginal peoples. Discuss research that has been conducted to substantiate that these important plant species can be re-established in the reclaimed landscape. Identify plant species important to aboriginal peoples that Shell intends to include in the species mix for reclaimed lands. Discuss consultation with the Aboriginal groups and their views on traditional uses in the reclaimed landscape.

Response

The *Traditional Land Use* report prepared by Fort McKay Environmental Services Ltd. identifies plants, including berry producers, that are important. Shell is consulting directly with Fort McKay through the Industry Relation Committee on the EIA and closure plan. Once key stakeholders have confirmed their preferred end-land uses, the final reclamation plan, including species mixes will be selected. Syncrude and Suncor's success at species establishments are identified in the Vegetation Reclamation Committee's draft manual, *Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region*.

Berry-producing species as well as other traditionally important plants would be considered for reclaimed lands.

Suncor and Syncrude have reclamation areas with good berry crops, including raspberries, saskatoons and strawberries. (Vegetation and Reclamation manual, Syncrude and Suncor research.)

Question No. 8.17

Shell No. AEP 141

Issue Reclamation and Closure - Land Use

Request 141.1 One of the fundamental considerations for the Oil Sands Mining End Land Use Committee is to assess the impact of the loss of productive forest lands on annual allowable cut (AAC) and determining which mitigation measures can be taken to reduce the impact on the forest industry *(Vol. III, p. E16-7)*. Describe the impact to the ACC for the regional and LSAs, for each commercial forest species. Include areas to be harvested, volume to be removed, and incremental return of the area to commercial forested landbase.

Response 141.1 EIA Volume 3, Part 1, Table E9-4, provides timber productivity ratings that are taken from the AVI results. Shell will coordinate with the forestry industry and government to seek resolution on AAC for the project area.

Request 141.2 Please provide documentation of consultation with forest harvesting companies regarding mitigation of the projected impact to their AAC *(Vol. I, p. 16-36)*. Discuss the results of such consultations.

Response 141.2 Shell has had various contacts with Alberta-Pacific, the Forest Management Agreement (FMA) holder, concerning volumes to be cut, impacts and annual operating plans. Shell has also been involved in meeting with government and regional players to discuss appropriateness of timber tonnage assessment value and future harvesting and operational plans of both Alberta-Pacific and Northlands, the permit holder.

Question No. 9.1

Shell No. AEP 142

Issue Public Health

Request With respect to aboriginal traditional land use, please describe the linkages, existing or proposed, between the traditional land use studies that are referenced in the Shell submission (*Vol. III, p. E15-1 and E15-16*) and the traditional resource use portion of the Wood Buffalo Environmental Association (WBEA), Terrestrial Environmental Effects Monitoring monitoring program.

Response The report prepared by the Fort McKay First Nations, entitled "There is still survival out there," provided an account of past traditional uses in the region by people in the Fort McKay community. It was primarily based on the recollections of elders in the community.

Shell has not been involved in the WBEA Terrestrial Environmental Effects Monitoring Program (TEEM) to date, and has attended RAQCC and WBEA meetings as an invited observer. However, Shell understands that TEEM is currently awaiting a proposal from Fort McKay Environmental Services for a project that would focus on traditional uses.

Question No. **9.2**

Shell No. **AEP 143**

Issue **Public Health**

Request

Shell states "Due to the lack of data on mammalian chronic toxicity of naphthenic acids, the potential for human health effects could not be evaluated for this group of substances" (*Vol. III, p. E12-26*). "Although the acute toxicity of naphthenic acids is generally low, hazards of chronic low level exposure could not be evaluated due to lack of toxicity data" (*Vol. III, p. E12-27*).

143.1 Please clarify. Discuss any contingencies to be put in place to address potential problems associated with naphthenic acid.

Response

143.1 The potential for human (and wildlife) health risks from exposure to naphthenic acids in CT water could not be quantitatively evaluated in the EIA because of insufficient chronic mammalian toxicity information. This was clearly identified as a data gap in the human (and wildlife) health assessments.

Shell is committed to working with other members of the oil sands industry to reduce this uncertainty and find ways to avoid or mitigate any effects.

Request

143.2 "Currently there is an industry initiative to collect the required data to resolve the issue of chronic exposures" *(Vol. III, p. E12-26 and E12-27)*. Comment on the naphthenic acid initiative and provide a description of the anticipated projects.

Response

143.2 Currently, oil sands industries are conducting tests to determine the chronic toxicity of naphthenic acids, using a phased approach. These studies have been spearheaded by individual industries, but regional cooperation is encouraged. As stated in AEP 143.1, Shell is committed to becoming involved in these research projects once the Muskeg River Mine Project is approved.

Question No. **9.3**

Shell No. **AEP 144**

Issue **Public Health**

Request

The Project is not expected to have an adverse affect on wildlife or human health from ingesting toxic waters, aquatic prey or plants during the operation or after mine closure *(Vol. I, p. 10-16)*.

Clarify the apparent contradiction with respect to Shell's conclusions for effects of naphthenic acids made in Vol. III, E12-26. Outline future research to be conducted to remove uncertainty with respect to naphthenic acids.

Response

Risk estimates have been computed for both human and wildlife receptors for all chemicals of potential concern, except naphthenic acids, because there is insufficient information available to support the computation of health risks arising from naphthenic acids. However, the available information on acute exposures suggests that naphthenic acids are relatively low in toxicity (see EIA Volume 3, Part 2, Appendix X). On this basis, and from the information in the EIA, adverse effects from chemicals are not expected, although additional information on naphthenic acids is necessary to remove this aspect of uncertainty.

See the response to AEP 143.1 and AEP 143.2.

Question No. **9.4**

Shell No. **AEP 145**

Issue **Public Health**

Request

Shell states "Total Petroleum Hydrocarbons (TPH) toxicity data are not available for all compounds of the hydrocarbon spectrum. Therefore, such chemical exposure and risks were conservatively estimated through the recent methods of the TPH Criteria Working Group" *(Vol. III, p. E12- 30).* Comment on why TPH assessment was completed for air emissions but apparently omitted from the assessment evaluating other exposure pathways (e.g., soil, food, water).

Response

Soil and Food: As part of the vegetation sampling program, soil and plant samples (blueberries, Labrador tea leaves and cattail root) were analyzed for PAHs. PAHs were not detected in most samples. In a few samples, naphthalenes and phenanthrene/anthracene were detected at levels marginally exceeding the detection limit. Based on these results, it was concluded that PAHs are not being accumulated by plants in the study area to levels that would be of concern to human health. In addition, recent animal tissue sampling conducted by Conor Pacific has confirmed the absence of food chain accumulation of PAHs. For these reasons, PAHs in soil and foods were not considered further.

With regard to other carbon fractions, data were not available in these environmental media, but were available for air. Many of these compounds are extremely volatile and, therefore, the most relevant route of exposure is air.

Water: The most toxic components of TPH were evaluated in the recreational and drinking water exposure scenarios (benzo[a]pyrene group, benzo[a]anthracene group). These chemical groups were selected based on chemical screening of waterborne chemical releases, consistent with two previously approved oil sands EIAs.

Question No. 9.5

Shell No. AEP 146

Issue Public Health

Request

Regulators and others have generally considered incremental lifetime cancer risks of less than 1E-06 acceptable and have considered risks greater than 1E-04 as unacceptable. Clarify why the cancer risk used is 1/100,000 and not 1/1,000,000? Comment on the significance of an ER between 0.5 and 1.0 at the higher [1/100,000] risk threshold used. Is an elevated risk level an appropriate indicator for follow-up monitoring?

Response

Two incremental lifetime cancer risk levels are generally accepted for use in human health risk assessments: 1 in 100,000 and 1 in 1,000,000. The selection of the most appropriate cancer risk level to use in this EIA was made in consultation with AEP. Use of a cancer risk level of 1 in 100,000 (1E-05) is consistent with methodologies used by AEP in other settings e.g., the development of risk-based soil criteria for contaminated sites. As this level of protection is acceptable for the province of Alberta, the magnitude of predicted exposures to carcinogenic chemicals was evaluated with respect to this incremental lifetime cancer risk level.

An exposure ratio (ER) between 0.5 and 1.0 at a risk threshold of 1 in 100,000 corresponds to an incremental lifetime cancer risk ranging from 1 in 200,000 to 1 in 100,000. This level of risk is considered to be "essentially negligible" with respect to overall cancer risks from other facts. Nevertheless, follow-up monitoring could be conducted to verify risk predictions and to ensure that cancer risk levels are within acceptable limits.

Other Jurisdictions:

The Canadian Drinking Water Guidelines for carcinogenic chemicals are derived based on acceptable incremental lifetime cancer risk levels of less than 1 in 100,000 to 1 in 1,000,000. This range is "generally considered to be essentially negligible" (HWC 1995). The Canadian Council of Ministers of the Environment derived the new Canadian Soil Quality Guidelines based on an incremental lifetime cancer risk of 1 in 1,000,000 in most cases, but also stated a range of less than 1 in 100,000 to 1 in 1,000,000 is generally acceptable (CCME 1997). The new Contaminated Sites Regulations in British Columbia states "a manager must consider a contaminated site to have been satisfactorily remediated ... if for any non-threshold carcinogenic substance, the calculated human lifetime cancer risk due to exposure to that substance at the site is less than or equal to 1 in 100,000..." (BC Environment 1997). Although Health Canada has not publicly released the guidance manual for human health risk assessment produced by Golder Associates and CanTox Inc. in 1995, they support the recommendations for the use of lifetime cancer risk levels in the range of 1 in 100,000 to 1 in 1,000,000.

Question No. 9.6

Shell No. AEP 147

Issue Public Health

Request

Shell states "The results suggest that short term (i.e. hourly data) air concentrations may occasionally reach peaks that are detectable on-site and possibly in Fort McKay" *(Vol. III, p. E12-36)*. Please comment on the impact of the tailings pond on the community of Fort McKay, particularly related to fugitive VOC and TRS emissions. Given the uncertainty regarding Tailings Pond emissions and its close proximity to Fort McKay, clarify how Shell will ensure that this community won't be impacted.

Response

The statement in EIA Volume 3, part 1, page E12-35, refers to odourous compounds, such as sulphides and mercaptans. Hourly concentrations of these substances might occasionally exceed odour thresholds during adverse atmospheric conditions. The peak hourly concentrations occur during adverse atmospheric events and do not represent consistent daily exposure concentrations. These odour thresholds are not associated with adverse health effects, but rather represent levels above which odours can be detected by people. Thus, exceedance of these thresholds does not indicate an adverse health effect.

Shell will ensure residents of Fort McKay will not be impacted by VOC and TRS emissions from the pond. Pond emissions will be monitored periodically during operations and following closure, and mitigation measures will be implemented as necessary to ensure Fort McKay residents are not impacted.

Question No. 9.7

Shell No. AEP 148

Issue Public Health

Request

Shell states that "ambient air monitoring and periodic personal air monitoring should be established". To achieve this, Shell is committed to be an active member and provide leadership in the Wood Buffalo Environmental Association (WBEA) and the Alberta Oilsands Community Exposure & Health Effects Assessment Program *(Vol. III, p. E12-39)*. Comment on:

148.1 the monitoring plan that will confirm the predicted high ER to some *compounds (Vol. III, p. E12-33, Table E12-6,)* is occupationally related

Response

148.1 Shell will work with the Wood Buffalo Environmental Association (WBEA) and the Alberta Oil Sands Community Exposure and Health Effects Assessment Program (AOSCEHEAP) committees to ensure that the regional monitoring programs are designed to meet the needs of the Muskeg River Mine Project.

Request 148.2 how monitoring plans will include integration with the WBEA network, and the Community Exposure and Health Effects Assessment Program

Response 148.2 AOSCEHEAP is a joint industry, government and community initiative to monitor airborne exposure in regional communities using data from personal air monitoring devices and community air monitoring stations. Health effects will also be monitored in this study. The WBEA has also designed an Environmental Effects Monitoring program to assess the effects of air emissions on vegetation. Shell will work closely with each of these programs to ensure that air quality monitoring programs are addressing their specific concerns. See also Attachment 9.

Request 148.3 what monitoring triggers will prompt a response from Shell and whether they will be discussed within the RAQCC/WBEA partnership.

Response 148.3 See the response to AEP 35 on Shell's Monitoring Committee.

Question No. **10.1**

Shell No. **AEP 149**

Issue **Historical Resources**

Request Shell states that the Mills Island well intake near Isadore's (Cree Burn) Lake is a superior location from an environmental impact and cost perspective *(Vol. I, p. 8-17, Figure 8.9)*. However, Shell is discussing its options and consulting with stakeholders.

149.1 Please provide an update of these options and public consultation.

Response 149.1 Subsequent investigation of the Isadore's Lake site using electrical resistivity tomography (ERT) has indicated that there is no hydraulic connection between the thick sand deposit below Isadore's Lake and the Athabasca River. The investigation also concluded that the thick sand deposit might be saturated with highly saline water. Given these results, Isadore's Lake is considered not suitable for an induced water well intake and the option will not be pursued.

During consultation with stakeholders and further review of possible intake locations, a preferred site for a river intake has been identified. This site is about 6.5 km downstream of the barge landing site adjacent to a narrow section in the river channel opposite Ing's Island. This site can be easily accessed from Highway 63 and is located in an area already disturbed by the construction of an old landing site. This site also provides for a more direct route to the Muskeg River Mine extraction facilities. This location is discussed further in Section 4.2, Water Management, in the Project Update.

Request 149.2 Regardless of the location chosen, describe the mitigation measures Shell will incorporate into the Project to reduce the aesthetic impact due to the water intake and associated pipeline ROW.

Response 149.2 Subsequent investigation of the Isadore's Lake site using electrical resistivity tomography (ERT) has indicated that there is no hydraulic connection between the thick sand deposit below Isadore's Lake and the Athabasca River. The investigation also concluded that the thick sand deposit might be saturated with highly saline water. Given these results, Isadore's Lake is considered not suitable for an induced water well intake and the option will not be pursued.

Regardless of the location chosen, Shell will mitigate the aesthetic impact of the river intake by offsetting the pumphouse from the river bank, where possible, providing vegetation screening and reclaiming areas disturbed by construction of the facilities. Similarly, the pipeline right-of-way will have designed offsets to limit the line of sight and will be reseeded with appropriate vegetation.

Question No. **10.2**

Shell No. **AEP 150**

Issue **Historical Resources**

Request Please provide information that will show the presence or absence of Historical Resource artifacts in the Syncrude/Shell utility corridor adjacent to Hwy 63 and the Cree Burn Lake PNT *(Terrain and Soil Baseline Report)*. Please describe the study design.

Response The utility corridor is Syncrude's facility, and historical resources are described in Syncrude's HRIA. The corridor is not part of Shell's HRIA permit area.

Question No. **11.1**

Shell No. **AEP 151**

Issue **Socio-Economic**

Request Describe the cumulative impacts to Highway 63 north of Fort McMurray, due to Shell's development *(Terrain and Soil Baseline)*. Outline any mitigation required. Please discuss the results of the oil sand industry review of Highway 63 traffic capacity for the Transportation Sub-Committee.

Response The Regional Municipality of Wood Buffalo Transportation Assessment determined that the initial work associated with development of the major projects has already resulted in increased traffic on Highway 63 and continuing increases in truck, bus and small vehicles are expected for the next few years. North of Fort McMurray, Highway 63 is a Class 1B, two-lane highway.

The transportation assessment evaluated the capacity of Highway 63 and the anticipated traffic volumes over the next few years. The analysis indicated that Highway 63, from Fort McMurray to Syncrude, will meet the criteria used by Alberta for highway twinning over both the short and long term.

Recommended mitigation is that the provincial government immediately make special funding available for the twinning of Highway 63 between Fort McMurray and the Suncor access. Twinning to the Syncrude site should be completed by summer 2000.

Building on the high level of existing traffic management activities in place, increased carpooling, worker bussing, incident management procedures to minimize traffic disruption, and staggered hours are identified as short term actions that can assist to help manage traffic volumes during construction, until twinning can be put in place.

The impacts of the Muskeg River Mine Project will be reduced over the construction period until 2002, through the use of camps so that most workers are at site, as well as the management of arrival times of heavy loads.

Industry continues to work together cooperatively through the RIWG Transportation Sub-committee to ensure that traffic impacts, issues and mitigations are clearly identified. Work continues to improve traffic management practices, and to work with local and provincial governments to have roads upgraded to accommodate development.

Attachment 1

Table 2 shows the alteration in pre-development aspects following mine development. Baseline aspects are variable with a slightly higher west (2656.8 ha or 24.3%) and east (1687.9 ha or 15.4%) aspects. East, Southeast, and west aspects will be slightly reduced due to mine developments. The most notable increase is Northwest aspects which are largely associated with the aboveground structures (i.e. Tailing Sands Dump).

Table 2 Alteration of Aspect in the LSA

Aspect	Pre-Development		Post-Development		% Change
	ha	%	ha	%	
Flat	77.5	0.7	119.8	1.1	0.4
North	599.1	5.5	861.5	7.9	2.4
Northeast	567.1	5.2	772.7	7.1	1.9
East	1687.9	15.4	1228.2	11.2	-4.2
Southeast	1656.9	15.1	1303.6	11.9	-3.2
South	1090.8	10.0	1217.9	11.1	1.2
Southwest	1357.3	12.4	1492.6	13.6	1.2
West	2656.8	24.3	2185.8	20.0	-4.3
Northwest	1260.2	11.5	1771.5	16.2	4.7
Total	**10953.6**	**100.0**	**10953.6**	**100.0**	**0.0**

Table 3 shows the alteration in pre-development aspects following mine development. The dominant baseline slopes are classified as level to nearly level (10284.2 ha or 93.9 %). These slopes will be reduced by 13.3 %. Although level to nearly level slopes will remain the dominant slope class in the LSA there will be increases in very gentle (7.8%), gentle (2.3%), moderate (1.8%) and strong (1.5%) slopes.

Table 3 Alteration of Slope in the LSA

SLOPE		Pre-Development		Post-Development		% Change
degrees		ha	%	ha	%	%
0-1	Level / Nearly Level	10284.2	93.9	8823.6	80.6	-13.3
2-3	Very Gentle Slopes	459.7	4.2	1313.9	12.0	7.8
4-5	Gentle Slopes	111.6	1.0	366.7	3.3	2.3
6-9	Moderate Slopes	50.6	0.5	244.8	2.2	1.8
10-15	Strong Slopes	43.4	0.4	202.5	1.8	1.5
16-30	Very Strong Slopes	4.1	<0.1	2.1	<0.1	<0.1
>31	Steep Slopes	0.0	0.0	0.0	0.0	0.0
	Total	**10953.6**	**100.0**	**10953.6**	**100.0**	**0.0**

Table E9-2 Vegetation (Ecosite Phases) Types Within the Local Study Area and Areas to be Cleared and Reclaimed for the Muskeg River Mine Project

Map Code	Ecosite Phases	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Degree of Concern
a1	Lichen Pj	Negative	High	Local	Long-term	Reversible	Low	Low
a1/g1 complex	Pj-Lt	Negative	High	Local	Long-term	Reversible	Low	Low
b1	Blueberry Pj-Aw	Negative	High	Local	Long-term	Reversible	Low	Low
b2	Blueberry Aw(Bw)	Negative	Low	Local	Long-term	Reversible	Low	Low
b3	Blueberry Aw-Sw	Negative	Low	Local	Long-term	Reversible	Low	Low
b4	Blueberry Sw-Pj	Negative	Low	Local	Long-term	Reversible	Low	Low
c1	Labrador Tea-mesic Pj-Sb	Negative	High	Local	Long-term	Reversible	Low	Low
d1	Low Bush Cranberry Aw	Negative	Low	Local	Long-term	Reversible	Low	Low
d2	Low Bush Cranberry Aw-Sw	Negative	Low	Local	Long-term	Reversible	Low	Low
d3	Low Bush Cranberry Sw	Negative	High	Local	Long-term	Reversible	Low	Low
e1	Dogwood Pb-Aw	Negative	High	Local	Long-term	Reversible	Low	Low
e1/f1	Pb-Aw	Negative	High	Local	Long-term	Reversible	Low	Low
e2	Dogwood Pb-Sw	Negative	High	Local	Long-term	Reversible	Low	Low
e2/f2	Pb-Sw	Negative	High	Local	Long-term	Reversible	Low	Low
e3	Dogwood Sw	Negative	Low	Local	Long-term	Reversible	Low	Low
g1	Labrador Tea-subhygric Sb-Pj	Negative	High	Local	Long-term	Reversible	Low	Low
h1	Labrador Tea/Horsetail Sw-Sb	Negative	High	Local	Long-term	Reversible	Low	Low

Attachment 3

Number of plots and species per ecosite phase.

		Total Species Richness (Number) Among Plots				
Class		All Species	Herbs	Shrubs	Trees	Number of Plots
a1	Lichen Pj	35	18	16	3	15
b1	Blueberry Pj-Aw	56	32	22	5	9
b2	Blueberry Aw-Bw	18	10	7	1	2
b3	Blueberry Aw-Sw	31	14	14	5	4
b4	Blueberry Sw-Pj	23	9	13	2	3
c1	Labrador Tea mesic Pj-Sb	40	22	17	4	6
d1	Low Bush Cranberry Aw	73	44	28	5	30
d2	Low Bush Cranberry Aw-Sw	71	44	28	5	26
d3	Low Bush Cranberry Sw	25	13	12	1	2
e1	Dogwood Pb-Aw	58	35	22	6	6
e2	Dogwood Pb-Sw	34	20	12	3	4
e3	Dogwood Sw	27	14	11	2	2
g1	Labrador Tea subhygric Sb-Pj	51	29	20	4	10
h1	Labrador Tea/Horsetail Sw-Sb	47	25	21	5	6
i1	Treed Bog	19	9	11	1	10
j1	Treed Poor Fen	62	42	21	2	14
j2	Shrubby Poor Fen	43	26	18	2	8
k1	Treed Rich Fen	78	53	25	3	21
k2	Shrubby Rich Fen	87	63	25	2	36
k3	Graminoid Rich Fen	8	5	3	0	4
BTNN	Treed Bog	19	9	11	1	10
FONS	Shrubby Fen	101	69	33	3	44
FTNN/FFNN	Treed Fen	97	68	30	3	35
FONG	Graminoid Fen	8	5	3	0	4
Grand Total		172	123	50	8	218

Attachment 4

A complete species list for each ecosite phase.

Attachment 4 (cont'd)

Species Lists

Attachment D

a1	b1	b2	b3	b4	c1	d1	d2
Agrostis/Agropyron spp.	Alnus crispa	Alnus crispa	Alnus crispa	Alnus crispa	Achillea millifolium	Achillea millifolium	Achillea millifolium
Alnus crispa	Amelanchier alnifolia	Amelanchier alnifolia	Amelanchier alnifolia	Amelanchier alnifolia	Alnus crispa	Agropyron trachycaulum	Agrostis/Agropyron spp.
Amelanchier alnifolia	Aralia nudicaulis	Aralia nudicaulis	Arctostapylos uva-ursi	Arctostapylos uva-ursi	Anemone pariflora	Agrostis/Agropyron spp.	Alnus crispa
Aralia nudicaulis	Arctostapylos uva-ursi	Arctostapylos uva-ursi	Betula occidentalis	Calamagrostis canadensis	Arctostapylos uva-ursi	Alnus crispa	Amelanchier alnifolia
Arctostapylos rubra	Aster ciliolatus	Betula papyrifera	Betula papyrifera	Carex siccatta	Aster spp.	Alnus tenufolia	Aralia nudicaulis
Arctostapylos uva-ursi	Betula glandulosa	Campanula rotundifolia	Carex spp.	Cornus canadensis	Betula glandulosa	Amelanchier alnifolia	Arctostapylos uva-ursi
Calamagrostis canadensis	Betula papyrifera	Carex spp.	Coptis trifolia	Fragaria virginiana	Betula occidentalis	Apocynum androsaemifolium	Arnica cordifolia
Carex spp.	Calamagrostis canadensis	Cornus canadensis	Cornus canadensis	Galium boreale	Betula papyrifera	Aralia nudicaulis	Aster spp.
Cornus canadensis	Cornus canadensis	Elymus canadensis	Cornus stolonifera	Geocaulon lividum	Calamagrostis canadensis	Arctostapylos uva-ursi	Betula glandulosa
Cypripedium calycantha	Elymus innovatus	Galium boreale	Epilobium angustifolia	Lathyrus ochroleucus	Carex spp.	Aster ciliolatus	Betula occidentalis
Elymus innovatus	Epilobium angustifolia	Lycopodium annotinum	Equisetum scirpoides	Linnaea borealis	Cornus canadensis	Aster spp.	Betula papyrifera
Festuca spp.	Fragaria virginiana	Lycopodium complanatum	Galium boreale	Maianthemum canadense	Elymus innovatus	Astralagus canadensis	Betula pumila
Fragaria virginiana	Lathyrus ochroleucus	Lycopodium obscurum	Geocaulon lividum	Orthilia secunda	Epilobium angustifolia	Betula glandulosa	Calamagrostis canadensis
Galium boreale	Ledum groenlandicum	Maianthemum canadense	Lathyrus ochroleucus	Picea glauca	Fragaria virginiana	Betula occidentalis	Carex spp.
Geocaulon lividum	Linnaea borealis	Populus tremuloides	Ledum groenlandicum	Pinus banksiana	Galium boreale	Betula papyrifera	Cornus canadensis
Goodyera repens	Lycopodium annotinum	Prunus pennsylvanica	Linnaea borealis	Populus balsamifera	Grass spp.	Calamagrostis canadensis	Cornus stolonifera
Ledum groenlandicum	Maianthemum canadense	Rosa acicularis	Lycopodium obscurum	Populus tremuloides	Hierochloe odorata	Carex atherodes	Elymus innovatus
Linnaea borealis	Menziesia ferruginea	Vaccinium myrtilloides	Maianthemum canadense	Ribes lacustre	Juncus spp.	Carex conncina	Epilobium angustifolia
Lycopodium complanatum	Orthilia secunda		Orthilia secunda	Rosa acicularis	Ledum groenlandicum	Carex spp.	Epilobium latifolia
Maianthemum canadense	Oryzopsis asperifolia		Oryzopsis asperifolia	Shepherdia canadensis	Lilium philidelphicum	Carex tenuiflora	Equisetum arvense
Orthilia secunda	Picea glauca		Petasites palmatus	Symphorocarpos alba	Linnaea borealis	Cornus canadensis	Equisetum scirpoides
Picea glauca	Picea mariana		Picea glauca	Vaccinium myrtilloides	Lycopodium clavatum	Cornus stolonifera	Equisetum spp.
Pinus banksiana	Pinus banksiana		Picea mariana	Vaccinium vitis-idaea	Lycopodium complanatum	Corylus cornuata	Fragaria virginiana
Populus balsamifera	Polygonum spp.		Pinus banksiana		Maianthemum canadense	Elymus canadensis	Galium boreale
Populus tremuloides	Populus balsamifera		Populus tremuloides		Petasites palmatus	Elymus innovatus	Geocaulon lividum
Pyrola virens	Populus tremuloides		Rosa acicularis		Picea glauca	Epilobium angustifolia	Goodyera repens
Rhamnus alnifolius	Potentilla fruticosa		Rubus pubescens		Picea mariana	Epilobium latifolia	Grass spp.
Rosa acicularis	Prunus pennsylvanica		Salix spp.		Pinus banksiana	Equisetum arvense	Hedysarum spp.
Rubus pubescens	Rosa acicularis		Shepherdia canadensis		Polygonum spp.	Equisetum pratense	Lathyrus ochroleucus
Salix spp.	Salix spp.		Vaccinium myrtilloides		Populus tremuloides	Fragaria virginiana	Ledum groenlandicum
Shepherdia canadensis	Shepherdia canadensis		Vaccinium vitis-idaea		Potentilla fruticosa	Galium boreale	Linnaea borealis
Solidago spp.	Unknown spp.				Rosa acicularis	Geocaulon lividum	Lonicera dioica
Vaccinium myrtilloides	Vaccinium myrtilloides				Rubus pubescens	Goodyera repens	Lonicera involucrata
Vaccinium vitis-idaea	Vaccinium vitis-idaea				Salix spp.	Habenaria orbiculata	Lycopodium annotinum
Viburnum edule	Vicia americana				Shepherdia canadensis	Lathyrus ochroleucus	Lycopodium clavatum
					Stellaria spp.	Ledum groenlandicum	Lycopodium complanatum
					Symphorocarpos alba	Linnaea borealis	Lycopodium obscurum
					Trientalis borealis	Lonicera dioica	Maianthemum canadense
					Vaccinium myrtilloides	Lycopodium annotinum	Mertensia paniculata
					Vaccinium vitis-idaea	Lycopodium complanatum	Mitella nuda
						Maianthemum canadense	Monesis uniflora
						Mertensia paniculata	Orthilia secunda
						Mitella nuda	Oryzopsis asperifolia
						Orthilia secunda	Oxycoccus microcarpus
						Oryzopsis asperifolia	Petasites palmatus
						Petasites palmatus	Picea glauca
						Picea glauca	Pinus banksiana
						Pinus banksiana	Polygonum spp.
						Populus balsamifera	Populus balsamifera
						Populus tremuloides	Populus tremuloides
						Potentilla fruticosa	Potentilla fruticosa
						Prunus pennsylvanica	Prunus virginiana
						Prunus virginiana	Pyrola asarifolia
						Pyrola asarifolia	Ribes lacustre
						Ribes lacustre	Ribes spp.
						Rosa acicularis	Ribes triste
						Rosa woodsi	Rosa acicularis
						Rubus arcticus	Rubus chamaemorus
						Rubus idaeus	Rubus pubescens
						Rubus pubescens	Salix spp.
						Salix spp.	Scizachne purpurescens
						Scizachne purpurescens	Shepherdia canadensis
						Shepherdia canadensis	Solidago spp.
						Smilacina trifolia	Symphorocarpos alba
						Symphorocarpos alba	Thalictrum venulosum
						Thalictrum venulosum	Trientalis borealis
						Trientalis borealis	Vaccinium myrtilloides
						Urtica dioica	Vaccinium vitis-idaea
						Vaccinium myrtilloides	Viburnum edule
						Vaccinium vitis-idaea	Vicia americana
						Viburnum edule	Viola spp.
						Vicia americana	
						Viola spp.	

Attachment 4 (cont'd)

Species Lists

d3	e1	e2	e3	g1	h1	i1	j1
Alnus tenufolia	Achillea millifolium	Alnus tenufolia	Abies balsamea	Achillea millifolium	Achillea millifolium	Alnus crispa	Achillea millifolium
Amelanchier alnifolia	Actaea rubra	Aralia nudicaulis	Alnus tenufolia	Alnus crispa	Agrostis/Agropyron spp.	Arctostapylos rubra	Alnus tenufolia
Apocynum androsaemifolium	Alnus crispa	Calla palustris	Amelanchier alnifolia	Anemone parifiora	Alnus tenufolia	Betula glandulosa	Andromeda polifolia
Aralia nudicaulis	Alnus tenufolia	Caltha palustris	Aralia nudicaulis	Arctostapylos uva-ursi	Amelanchier alnifolia	Calamagrostis canadensis	Arctostapylos rubra
Arctostapylos uva-ursi	Amelanchier alnifolia	Cornus canadensis	Aster spp.	Aster spp.	Arctostapylos uva-ursi	Carex spp.	Betula glandulosa
Cornus canadensis	Aralia nudicaulis	Cornus stolonifera	Cornus canadensis	Betula glandulosa	Aster spp.	Chaemaedaphne calculata	Betula occidentalis
Elymus innovatus	Aster spp.	Elymus innovatus	Cornus stolonifera	Calamagrostis canadensis	Betula papyrifera	Equisetum arvense	Betula papyrifera
Equisetum arvense	Betula occidentalis	Epilobium angustifolia	Corylus cornuata	Carex aurea	Calamagrostis canadensis	Eriophorum chamissonis	Calamagrostis canadensis
Galium boreale	Betula papyrifera	Equisetum scirpoides	Equisetum scirpoides	Carex spp.	Carex spp.	Eriophorum vaginatum	Calla palustris
Lathyrus ochroleucus	Calamagrostis canadensis	Equisetum spp.	Equisetum sylvaticum	Chaemaedaphne calculata	Chaemaedaphne calculata	Kalmia microphylla	Carex aquatilis
Linnaea borealis	Carex disperma	Eriophorum angustifolium	Fragaria virginiana	Cornus canadensis	Clintonia uniflora	Kalmia polifolia	Carex atherodes
Maianthemum canadense	Carex spp.	Galium boreale	Galium boreale	Elymus innovatus	Cornus canadensis	Ledum groenlandicum	Carex conncina
Mertensia paniculata	Cinna latifolia	Galium trifidum/triflorum	Galium trifidum/triflorum	Epilobium angustifolia	Corylus cornuata	Maianthemum canadense	Carex spp.
Mitella nuda	Clintonia uniflora	Grass spp.	Linnaea borealis	Equisetum arvense	Elymus innovatus	Oxycoccus microcarpus	Chaemaedaphne calculata
Petasites palmatus	Cornus canadensis	Linnaea borealis	Mitella nuda	Equisetum palustre	Equisetum arvense	Picea mariana	Clintonia uniflora
Picea glauca	Cornus stolonifera	Lonicera involucrata	Monesis uniflora	Equisetum scirpoides	Fragaria virginiana	Rubus chamaemorus	Cornus canadensis
Pyrola asarifolia	Epilobium angustifolia	Maianthemum canadense	Petasites palmatus	Equisetum spp.	Galium boreale	Salix spp.	Drosera rotundifolia
Rhamnus alnifollius	Equisetum scirpoides	Mertensia paniculata	Picea glauca	Equisetum sylvaticum	Grass spp.	Smilacina trifolia	Elymus innovatus
Ribes triste	Equisetum spp.	Mitella nuda	Pyrola asarifolia	Fragaria virginiana	Larix laricina	Vaccinium vitis-idaea	Epilobium angustifolia
Rosa acicularis	Equisetum sylvaticum	Petasites palmatus	Ribes spp.	Galium boreale	Lathyrus ochroleucus		Epilobium leptophyllum
Rubus pubescens	Fragaria virginiana	Picea glauca	Ribes triste	Geocaulon lividum	Ledum groenlandicum		Equisetum arvense
Shepherdia canadensis	Galium boreale	Populus balsamifera	Rosa acicularis	Hedysarum spp.	Linnaea borealis		Equisetum pratense
Symphorocarpos alba	Galium trifidum/triflorum	Populus tremuloides	Rosa woodsi	Kalmia microphylla	Lonicera dioica		Equisetum scirpoides
Vaccinium myrtilloides	Grass spp.	Pyrola asarifolia	Rubus pubescens	Larix laricina	Maianthemum canadense		Equisetum spp.
Viburnum edule	Juncus spp.	Ribes lacustre	Symphorocarpos alba	Ledum groenlandicum	Mitella nuda		Equisetum sylvaticum
	Larix laricina	Rosa aciculans	Viburnum edule	Linnaea borealis	Oryzopsis asperifolia		Eriophorum chamissonis
	Lathyrus ochroleucus	Rubus idaeus	Viola spp.	Lycopodium clavatum	Oxycoccus microcarpus		Fragaria virginiana
	Ledum groenlandicum	Rubus pubescens		Mitella nuda	Petasites palmatus		Galium boreale
	Linnaea borealis	Salix spp.		Orthillia secunda	Petasites sagittatus		Galium trifidum/triflorum
	Lonicera dioica	Shepherdia canadensis		Oxycoccus microcarpus	Picea glauca		Geocaulon lividum
	Lonicera involucrata	Symphorocarpos alba		Petasites palmatus	Picea mariana		Habenaria spp.
	Lycopodium annotinum	Trientalis borealis		Picea mariana	Pinus banksiana		Larix laricina
	Maianthemum canadense	Viburnum edule		Pinus banksiana	Polygonum spp.		Ledum groenlandicum
	Mertensia paniculata	Vicia americana		Populus balsamifera	Populus tremuloides		Linnaea borealis
	Mitella nuda			Populus tremuloides	Potentilla fruticosa		Lysimachia thyrsflora
	Monesis uniflora			Potentilla fruticosa	Pyrola virens		Maianthemum canadense
	Orthillia secunda			Pyrola asarifolia	Ribes spp.		Menziesia ferruginea
	Petasites palmatus			Rosa acicularis	Rosa acicularis		Mitella nuda
	Picea glauca			Rubus chamaemorus	Rubus chamaemorus		Myrica gale
	Picea mariana			Rubus pubescens	Rubus pubescens		Orchis rotundifolia
	Populus balsamifera			Salix arcticus	Salix spp.		Orthilia secunda
	Populus tremuloides			Salix myrtillifolia	Shepherdia canadensis		Oryzopsis asperifolia
	Ranunculus lapponicus			Salix spp.	Smilacina trifolia		Oxycoccus microcarpus
	Ribes triste			Shepherdia canadensis	Symphorocarpos alba		Petasites palmatus
	Rosa acicularis			Smilacina trifolia	Trientalis borealis		Petasites sagittatus
	Rubus chamaemorus			Solidago spp.	Vaccinium myrtilloides		Picea glauca
	Rubus idaeus			Symphorocarpos alba	Vaccinium vitis-idaea		Picea mariana
	Rubus pubescens			Vaccinium myrtilloides			Polygonum spp.
	Salix spp.			Vaccinium vitis-idaea			Potentilla fruticosa
	Shepherdia canadensis			Viburnum edule			Potentilla palustris
	Smilacina trifolia			Viola spp.			Pyrola asarifolia
	Symphorocarpos alba						Rosa acicularis
	Thalictrum venulosum						Rubus arcticus
	Trientalis borealis						Rubus chamaemorus
	Vaccinium myrtilloides						Rubus pubescens
	Vaccinium vitis-idaea						Salix athabascensis
	Viburnum edule						Salix myrtillifolia
	Vicia americana						Salix spp.
							Smilacina trifolia
							Spiranthes romanzoffiana
							Stellaria crassifolia
							Vaccinium vitis-idaea

Attachment 4 (cont'd)

Species Lists

j2	k1	k2	k3	BTNN	FONS	FTNN/FFNN	FONG
Achillea millifolium	Alnus crispa	Achillea millifolium	Betula glandulosa	Alnus crispa	Achillea millifolium	Achillea millifolium	Betula glandulosa
Agrostis/Agropyron spp.	Alnus tenufolia	Achillea sibrica	Carex spp.	Arctostapylos rubra	Achillea sibrica	Alnus crispa	Carex spp.
Arctostapylos rubra	Andromeda polifolia	Alnus crispa	Equisetum spp.	Betula glandulosa	Agrostis/Agropyron spp.	Alnus tenufolia	Equisetum spp.
Aster cileolatus	Aralia nudicaulis	Alnus tenufolia	Grass spp.	Calamagrostis canadensis	Alnus crispa	Andromeda polifolia	Grass spp.
Betula glandulosa	Aster cileolatus	Andromeda polifolia	Juncus spp.	Carex spp.	Alnus tenufolia	Aralia nudicaulis	Juncus spp.
Betula occidentalis	Betula glandulosa	Arabis spp.	Kalmia polifolia	Chaemaedaphne calculata	Andromeda polifolia	Arctostapylos rubra	Kalmia polifolia
Betula papyrifera	Betula occidentalis	Aster modestus	Potentilla palustris	Equisetum arvense	Arabis spp.	Aster cileolatus	Potentilla palustris
Calamagrostis canadensis	Betula papyrifera	Aster spp.	Salix spp.	Eriophorum chamissonis	Arctostapylos rubra	Betula glandulosa	Salix spp.
Carex aquatilis	Betula pumila	Betula glandulosa		Eriophorum vaginatum	Aster cileolatus	Betula occidentalis	
Carex disperma	Calamagrostis canadensis	Betula occidentalis		Kalmia microphylla	Aster modestus	Betula papyrifera	
Carex limosa	Calla palustris	Betula papyrifera		Kalmia polifolia	Aster spp.	Betula pumila	
Carex rostrata	Caltha palustris	Calamagrostis canadensis		Ledum groenlandicum	Betula glandulosa	Calamagrostis canadensis	
Carex spp.	Carex aquatilis	Calla palustris		Maianthemum canadense	Betula occidentalis	Calla palustris	
Chaemaedaphne calculata	Carex atherodes	Caltha palustris		Oxycoccus microcarpus	Betula papyrifera	Caltha palustris	
Equisetum scirpoides	Carex disperma	Carex aquatilis		Picea mariana	Calamagrostis canadensis	Carex aquatilis	
Fragaria virginiana	Carex interior	Carex atherodes		Rubus chamaemorus	Calla palustris	Carex atherodes	
Galium trifidum/triflorum	Carex limosa	Carex disperma		Salix spp.	Caltha palustris	Carex conncina	
Grass spp.	Carex rostrata	Carex limosa		Smilacina trifolia	Carex aquatilis	Carex disperma	
Kalmia polifolia	Carex siccatta	Carex rostrata		Vaccinium vitis-idaea	Carex atherodes	Carex interior	
Larix laricina	Carex spp.	Carex spp.			Carex disperma	Carex limosa	
Ledum groenlandicum	Carex tenuiflora	Cornus stolonifera			Carex limosa	Carex rostrata	
Maianthemum canadense	Clintonia uniflora	Epilobium angustifolia			Carex rostrata	Carex siccatta	
Medicago sativa	Cornus canadensis	Epilobium ciliolatus			Carex spp.	Carex spp.	
Menziesia ferruginea	Cypripedium calycantha	Epilobium latifolia			Chaemaedaphne calculata	Carex tenuiflora	
Monesis uniflora	Drosera rotundifolia	Equisetum arvense			Cornus stolonifera	Chaemaedaphne calculata	
Oxycoccus microcarpus	Epilobium angustifolia	Equisetum scirpoides			Epilobium angustifolia	Clintonia uniflora	
Parnassia palustris	Equisetum arvense	Equisetum spp.			Epilobium ciliolatus	Cornus canadensis	
Picea glauca	Equisetum fluviatile	Eriophorum angustifolium			Epilobium latifolia	Cypripedium calycantha	
Picea mariana	Equisetum spp.	Festuca rubra			Equisetum arvense	Drosera rotundifolia	
Polygonum spp.	Equisetum variegatum	Fragaria virginiana			Equisetum scirpoides	Elymus innovatus	
Potentilla fruticosa	Eriophorum angustifolium	Galium boreale			Equisetum spp.	Epilobium angustifolia	
Potentilla palustris	Eriophorum chamissonis	Galium trifidum/triflorum			Eriophorum angustifolium	Epilobium leptophyllum	
Prunus pennsylvanica	Festuca spp.	Glyceria grandis			Festuca rubra	Equisetum arvense	
Ranunculus lapponicus	Fragaria virginiana	Grass spp.			Fragaria virginiana	Equisetum fluviatile	
Rosa acicularis	Galium boreale	Hippuris vulgaris			Galium boreale	Equisetum pratense	
Rubus chamaemorus	Galium labridoricum	Larix laricina			Galium trifidum/triflorum	Equisetum scirpoides	
Rubus pubescens	Galium trifidum/triflorum	Ledum groenlandicum			Glyceria grandis	Equisetum spp.	
Salix spp.	Grass spp.	Linnaea borealis			Grass spp.	Equisetum sylvaticum	
Smilacina trifolia	Habenaria spp.	Luzula spp.			Hippuris vulgaris	Equisetum variegatum	
Spiranthes romanzoffiana	Kalmia microphylla	Lysimachia thyrisflora			Kalmia polifolia	Eriophorum angustifolium	
Symphorocarpos alba	Kalmia polifolia	Maianthemum canadense			Larix laricina	Eriophorum chamissonis	
Unknown spp.	Larix laricina	Melampyrum lineare			Ledum groenlandicum	Festuca spp.	
Vaccinium vitis-idaea	Lathyrus ochroleucus	Mentha arvensis			Linnaea borealis	Fragaria virginiana	
	Ledum groenlandicum	Menyanthes trifoliata			Luzula spp.	Galium boreale	
	Linnaea borealis	Mertensia paniculata			Lysimachia thyrisflora	Galium labridoricum	
	Lonicera dioica	Mitella nuda			Maianthemum canadense	Galium trifidum/triflorum	
	Lysimachia thyrisflora	Myrica gale			Medicago sativa	Geocaulon lividum	
	Maianthemum canadense	Orthillia secunda			Melampyrum lineare	Grass spp.	
	Menyanthes trifoliata	Oxycoccus microcarpus			Mentha arvensis	Habenaria spp.	
	Menziesia ferruginea	Parnassia palustris			Menyanthes trifoliata	Kalmia microphylla	
	Mertensia paniculata	Petasites palmatus			Menziesia ferruginea	Kalmia polifolia	
	Mitella nuda	Petasites sagittatus			Mertensia paniculata	Larix laricina	
	Monesis uniflora	Picea glauca			Mitella nuda	Lathyrus ochroleucus	
	Orthillia secunda	Picea mariana			Monesis uniflora	Ledum groenlandicum	
	Oxycoccus microcarpus	Poa pratensis			Myrica gale	Linnaea borealis	
	Petasites palmatus	Polygonum spp.			Orthillia secunda	Lonicera dioica	
	Petasites sagittatus	Populus tremuloides			Oxycoccus microcarpus	Lysimachia thyrisflora	
	Picea glauca	Potentilla palustris			Parnassia palustris	Maianthemum canadense	
	Picea mariana	Pyrola asarifolia			Petasites palmatus	Menyanthes trifoliata	
	Poa pratensis	Ranunculus gmelinii			Petasites sagittatus	Menziesia ferruginea	
	Potentilla fruticosa	Rhamnus alnifoilius			Picea glauca	Mertensia paniculata	
	Potentilla palustris	Ribes lacustre			Picea mariana	Mitella nuda	
	Pyrola asarifolia	Ribes oxyacanthoides			Poa pratensis	Monesis uniflora	
	Ribes triste	Ribes triste			Polygonum spp.	Myrica gale	
	Rosa acicularis	Rubus arcticus			Populus tremuloides	Orchis rotundifolia	
	Rubus arcticus	Rubus chamaemorus			Potentilla fruticosa	Orthillia secunda	
	Rubus pubescens	Rubus pubescens			Potentilla palustris	Oryzopsis asperifolia	
	Rumex occidentailis	Rumex occidentailis			Prunus pennsylvanica	Oxycoccus microcarpus	
	Salix spp.	Salix prolixa			Pyrola asarifolia	Petasites palmatus	
	Shepherdia canadensis	Salix spp.			Ranunculus gmelinii	Petasites sagittatus	
	Smilacina trifolia	Scirpus spp.			Ranunculus lapponicus	Picea glauca	
	Solidago spp.	Scuttelaria galericulata			Rhamnus alnifoilius	Picea mariana	
	Symphorocarpos alba	Senecio vulgaris			Ribes lacustre	Poa pratensis	
	Tofieldia glutinosa	Shepherdia canadensis			Ribes oxyacanthoides	Polygonum spp.	
	Trientalis borealis	Smilacina racemosa			Ribes triste	Potentilla fruticosa	
	Triglochin spp.	Smilacina trifolia			Rosa acicularis	Potentilla palustris	
	Vaccinium vitis-idaea	Solidago spp.			Rubus arcticus	Pyrola asarifolia	
	Viburnum edule	Stellaria crassifolia			Rubus chamaemorus	Ribes triste	
		Stelleria spp.			Rubus pubescens	Rosa acicularis	
		Taraxacum officianale			Rumex occidentailis	Rubus arcticus	
		Triglochin spp.			Salix prolixa	Rubus chamaemorus	
		Unknown spp.			Salix spp.	Rubus pubescens	
		Urtica dioica			Scirpus spp.	Rumex occidentailis	
		Vaccinium myrtilloides			Scuttelaria galericulata	Salix athabascensis	
		Vaccinium spp.			Senecio vulgaris	Salix myrtillifolia	
		Vaccinium vitis-idaea			Shepherdia canadensis	Salix spp.	
		Vicia americana			Smilacina racemosa	Shepherdia canadensis	
					Smilacina trifolia	Smilacina trifolia	
					Solidago spp.	Solidago spp.	
					Spiranthes romanzoffiana	Spiranthes romanzoffiana	
					Stellaria crassifolia	Stellaria crassifolia	
					Stelleria spp.	Symphorocarpos alba	
					Symphorocarpos alba	Tofieldia glutinosa	
					Taraxacum officianale	Trientalis borealis	
					Triglochin spp.	Triglochin spp.	
					Unknown spp.	Vaccinium vitis-idaea	
					Urtica dioica	Viburnum edule	
					Vaccinium myrtilloides		
					Vaccinium spp.		
					Vaccinium vitis-idaea		
					Vicia americana		

Attachment 4 (cont'd)

Table 2 Species observed in each Alberta Wetland Inventory Class (in response to AEP 53.5)

BTNN	FONS	FTNN/FFNN	FOPN	FONG	MONG/WONN	STNN/SFNN	SONS
Alnus crispa	Achillea millifolium	Achillea millifolium	Achillea millifolium	Betula glandulosa	Calamagrostis canadensis	Achillea millifolium	Calamagrostis canadensis
Arctostapylos rubra	Achillea sibrica	Alnus crispa	Alnus tenufolia	Carex spp.	Carex aquatilis	Actaea rubra	Carex aquatilis
Betula glandulosa	Agrostis/Agropyron spp.	Alnus tenufolia	Andromeda polifolia	Equisetum spp.	Carex lacustris	Alnus crispa	Carex lacustris
Calamagrostis canadensis	Alnus crispa	Andromeda polifolia	Arctostapylos rubra	Grass spp.	Eleocharis palustris	Alnus tenufolia	Eleocharis palustris
Carex spp.	Alnus tenufolia	Aralia nudicaulis	Betula glandulosa	Juncus spp.	Equisetum arvense	Amelanchier alnifolia	Equisetum arvense
Chaemaedaphne calculata	Andromeda polifolia	Arctostapylos rubra	Betula occidentalis	Kalmia polifolia	Equisetum fluviatile	Aralia nudicaulis	Equisetum fluviatile
Equisetum arvense	Arabis spp.	Aster cileolatus	Betula papyrifera	Potentilla palustris	Hippuris vugaris	Aster spp.	Hippuris vugaris
Eriophorum chamissonis	Arctostapylos rubra	Betula glandulosa	Calamagrostis canadensis	Salix spp.	Juncus balticus	Betula occidentalis	Juncus balticus
Eriophorum vaginatum	Aster cileolatus	Betula occidentalis	Calla palustris		Nymphaea tetragona leibergii	Betula papyrifera	Nymphaea tetragona leibergii
Kalmia microphylla	Aster modestus	Betula papyrifera	Carex aquatilis		Polygonum lapathifolium	Calamagrostis canadensis	Polygonum lapathifolium
Kalmia polifolia	Aster spp.	Betula pumila	Carex atherodes		Potemegeton spp.	Carex disperma	Potemegeton spp.
Ledum groenlandicum	Betula glandulosa	Calamagrostis canadensis	Carex conncina		Potentilla fruticosa	Carex spp.	Potentilla fruticosa
Maianthemum canadense	Betula occidentalis	Calla palustris	Carex spp.		Potentilla palustris	Cinna latifolia	Potentilla palustris
Oxycoccus microcarpus	Betula papyrifera	Caltha palustris	Chaemaedaphne calculata		Salix discolor	Clintonia uniflora	Salix discolor
Picea mariana	Calamagrostis canadensis	Carex aquatilis	Cornus canadensis		Salix exigua	Cornus canadensis	Salix exigua
Rubus chamaemorus	Calla palustris	Carex atherodes	Elymus innovatus		Salix mackenzieana	Cornus stolonifera	Salix mackenzieana
Salix spp.	Caltha palustris	Carex conncina	Epilobium angustifolia		Sparganium spp.	Epilobium angustifolia	Sparganium spp.
Smilacina trifolia	Carex aquatilis	Carex disperma	Epilobium leptophyllum		Spartina pectinata	Equisetum scirpoides	Spartina pectinata
Vaccinium vitis-idaea	Carex atherodes	Carex interior	Equisetum arvense		Typha latifolia	Equisetum spp.	Typha latifolia
	Carex disperma	Carex limosa	Equisetum pratense		Utricularia minor	Equisetum sylvaticum	Utricularia minor
	Carex limosa	Carex rostrata	Equisetum scirpoides		Utricularia vulgaris	Fragaria virginiana	Utricularia vulgaris
	Carex rostrata	Carex siccatta	Equisetum spp.			Galium boreale	
	Carex spp.	Carex spp.	Equisetum sylvaticum			Galium trifidum/triflorum	
	Chaemaedaphne calculata	Carex tenuiflora	Eriophorum chamissonis			Grass spp.	
	Cornus stolonifera	Chaemaedaphne calculata	Fragaria virginiana			Juncus spp.	
	Epilobium angustifolia	Clintonia uniflora	Galium boreale			Larix laricina	
	Epilobium ciliolatus	Cornus canadensis	Galium trifidum/trifloru m			Lathyrus ochroleucus	
	Epilobium latifolia	Cypripedium calycantha	Geocaulon lividum			Ledum groenlandicum	
	Equisetum	Drosera	Habenaria spp.			Linnaea borealis	

Attachment 4 (cont'd)

BTNN	FONS	FTNN/FFNN	FOPN	FONG	MONG/WONN	STNN/SFNN	SONS
	arvense	rotundifolia					
	Equisetum scirpoides	Elymus innovatus	Larix laricina			Lonicera dioica	
	Equisetum spp.	Epilobium angustifolia	Ledum groenlandicum			Lonicera involucrata	
	Eriophorum angustifolium	Epilobium leptophyllum	Linnaea borealis			Lycopodium annotinum	
	Festuca rubra	Equisetum arvense	Lysimachia thyrisflora			Maianthemum canadense	
	Fragaria virginiana	Equisetum fluviatile	Maianthemum canadense			Mertensia paniculata	
	Galium boreale	Equisetum pratense	Menziesia ferruginea			Mitella nuda	
	Galium trifidum/trifloru m	Equisetum scirpoides	Mitella nuda			Monesis uniflora	
	Glyceria grandis	Equisetum spp.	Myrica gale			Orthillia secunda	
	Grass spp.	Equisetum sylvaticum	Orchis rotundifolia			Petasites palmatus	
	Hippuris vulgaris	Equisetum variegatum	Orthillia secunda			Picea glauca	
	Kalmia polifolia	Eriophorum angustifolium	Oryzopsis asperifolia			Picea mariana	
	Larix laricina	Eriophorum chamissonis	Oxycoccus microcarpus			Populus balsamifera	
	Ledum groenlandicum	Festuca spp.	Petasites palmatus			Populus tremuloides	
	Linnaea borealis	Fragaria virginiana	Petasites sagittatus			Ranunculus lapponicus	
	Luzula spp.	Galium boreale	Picea glauca			Ribes triste	
	Lysimachia thyrisflora	Galium labridoricum	Picea mariana			Rosa acicularis	
	Maianthemum canadense	Galium trifidum/trifloru m	Polygonum spp.			Rubus chamaemorus	
	Medicago sativa	Geocaulon lividum	Potentilla fruticosa			Rubus idaeus	
	Melampyrum lineare	Grass spp.	Potentilla palustris			Rubus pubescens	
	Mentha arvensis	Habenaria spp.	Pyrola asarifolia			Salix spp.	
	Menyanthes trifoliata	Kalmia microphylla	Rosa acicularis			Shepherdia canadensis	
	Menziesia ferruginea	Kalmia polifolia	Rubus arcticus			Smilacina trifolia	
	Mertensia paniculata	Larix laricina	Rubus chamaemorus			Symphorocarpos alba	
	Mitella nuda	Lathyrus ochroleucus	Rubus pubescens			Thalictrum venulosum	
	Monesis uniflora	Ledum groenlandicum	Salix athabascensis			Trientalis borealis	
	Myrica gale	Linnaea borealis	Salix myrtillifolia			Vaccinium myrtilloides	
	Orthillia secunda	Lonicera dioica	Salix spp.			Vaccinium vitis-idaea	
	Oxycoccus microcarpus	Lysimachia thyrisflora	Smilacina trifolia			Viburnum edule	
	Parnassia palustris	Maianthemum canadense	Spiranthes romanzoffiana			Vicia americana	
	Petasites palmatus	Menyanthes trifoliata	Stellaria crassifolia				
	Petasites sagittatus	Menziesia ferruginea	Vaccinium vitis-idaea				
	Picea glauca	Mertensia paniculata					

Attachment 4 (cont'd)

BTNN	FONS	FTNN/FFNN	FOPN	FONG	MONG/WONN	STNN/SFNN	SONS
	Picea mariana	Mitella nuda					
	Poa pratensis	Monesis uniflora					
	Polygonum spp.	Myrica gale					
	Populus tremuloides	Orchis rotundifolia					
	Potentilla fruticosa	Orthillia secunda					
	Potentilla palustris	Oryzopsis asperifolia					
	Prunus pennsylvanica	Oxycoccus microcarpus					
	Pyrola asarifolia	Petasites palmatus					
	Ranunculus gmelinii	Petasites sagittatus					
	Ranunculus lapponicus	Picea glauca					
	Rhamnus alnifoilius	Picea mariana					
	Ribes lacustre	Poa pratensis					
	Ribes oxyacanthoides	Polygonum spp.					
	Ribes triste	Potentilla fruticosa					
	Rosa acicularis	Potentilla palustris					
	Rubus arcticus	Pyrola asarifolia					
	Rubus chamaemorus	Ribes triste					
	Rubus pubescens	Rosa acicularis					
	Rumex occidentailis	Rubus arcticus					
	Salix prolixa	Rubus chamaemorus					
	Salix spp.	Rubus pubescens					
	Scirpus spp.	Rumex occidentailis					
	Scuttelaria galericulata	Salix athabascensis					
	Senecio vulgaris	Salix myrtillifolia					
	Shepherdia canadensis	Salix spp.					
	Smilacina racemosa	Shepherdia canadensis					
	Smilacina trifolia	Smilacina trifolia					
	Solidago spp.	Solidago spp.					
	Spiranthes romanzoffiana	Spiranthes romanzoffiana					
	Stellaria crassifolia	Stellaria crassifolia					
	Stelleria spp.	Symphorocarpos alba					
	Symphorocarpos alba	Tofieldia glutinosa					
	Taraxacum officianale	Trientalis borealis					
	Triglochin spp.	Triglochin spp.					
	Unknown spp.	Vaccinium vitis-idaea					
	Urtica dioica	Viburnum edule					

Attachment 5

Table E11-8 Construction and Operation Related Impacts of Change in Wildlife Habitat (Key Question W-1)

KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency
moose	Negative	High	Local-Regional	Long-Term	Reversible	Low-High
red-backed vole	Negative	High	Local	Long-Term	Reversible	Low-High
snowshoe hare	Negative	High	Local	Long-Term	Reversible	Low-High
black bear	Negative	High	Local-Regional	Long-Term	Reversible	Low-High
beaver	Negative	High	Local	Long-Term	Reversible	Low-High
fisher	Negative	High	Local-Regional	Long-Term	Reversible	Low-High
dabbling ducks	Negative	High	Local-Regional	Long-Term	Reversible	Low-High
ruffed grouse	Negative	High	Local	Long-Term	Reversible	Low-High
Cape May warbler	Negative	High	Local	Long-Term	Reversible	Low-High
western tanager	Negative	High	Local	Long-Term	Reversible	Low-High
pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Low-High
great gray owl	Negative	High	Local	Long-Term	Reversible	Low-High

Table E11-12 Susceptibility of Key Indicator Resources to Direct Mortality During Site Clearing

KIR	Winter	Spring
moose	Low	Low
red-backed vole	High	High
snowshoe hare	Moderate	Moderate
black bear	Moderate	Low
beaver	Low [1]	High
fisher	Low	High
dabbling ducks	Low	High
ruffed grouse	Low	High
Cape May warbler	Low	High
western tanager	Low	High
pileated woodpecker	Low	High
great gray owl	Low [2]	High

1 Direct mortality of beavers is considered to be low during winter as beavers are not active on land during this season; however beavers would be susceptible to mortality if their lodge was destroyed.

2 Direct mortality of great gray owls is low for most of the winter, but as these owls nest in late winter, their susceptibility to direct mortality is increased at that time.

Attachment 5 (cont'd)

Table E11-15 Construction and Operation Related Impacts of Change in Wildlife Abundance or Diversity (Key Question W-5)

KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency
Moose	Negative	High	Local - Regional	Long-Term	Reversible	Low-High
Red-Backed Vole	Negative	High	Local	Long-Term	Reversible	Low-High
Snowshoe Hare	Negative	High	Local	Long-Term	Reversible	Low-High
Black Bear	Negative	High	Local - Regional	Long-Term	Reversible	Low-High
Beaver	Negative	High	Local	Long-Term	Reversible	Low-High
Fisher	Negative	High	Local - Regional	Long-Term	Reversible	Low-High
Dabbling Ducks	Negative	High	Local - Regional	Long-Term	Reversible	Low-High
Ruffed Grouse	Negative	High	Local	Long-Term	Reversible	Low-High
Cape May Warbler	Negative	High	Local	Long-Term	Reversible	Low-High
Western Tanager	Negative	High	Local	Long-Term	Reversible	Low-High
Pileated Woodpecker	Negative	High	Local	Long-Term	Reversible	Low-High
Great Gray Owl	Negative	High	Local	Long-Term	Reversible	Low-High

1. The positive effects of reclamation are not considered in this table (see Table E11-16).

Table E11-16 Change in Wildlife Habitat, Over Baseline Conditions, due to Reclamation (Key Question W-6)

KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency
moose	Positive	Low	Local - Regional	Long-Term	Reversible	Low-High
red-backed vole	Positive	Low	Local	Long-Term	Reversible	Low-High
snowshoe hare	Negative	Low	Local	Long-Term	Reversible	Low-High
black bear	Positive	High	Local - Regional	Long-Term	Reversible	Low-High
beaver	Negative	Low	Local	Long-Term	Reversible	Low-High
fisher	Positive	Low	Local - Regional	Long-Term	Reversible	Low-High
dabbling ducks	Positive	High	Local - Regional	Long-Term	Reversible	Low-High
ruffed grouse	Positive	Moderate	Local	Long-Term	Reversible	Low-High
Cape May warbler	Positive	High	Local	Long-Term	Reversible	Low-High
western tanager	Positive	High	Local	Long-Term	Reversible	Low-High
pileated woodpecker	Positive	High	Local	Long-Term	Reversible	Low-High
great gray owl	Positive	Moderate	Local	Long-Term	Reversible	Low-High

July: moose HUs increase by 9.6% over baseline. This is a low magnitude increase.

Attachment 5 (cont'd)

Table E11-18 Impact of Reclamation [1] on Wildlife Abundance and Diversity (Key Question W-8)

KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency
moose	Positive	Low	Local-Regional	Long-Term	Reversible	Low-High
red-backed vole	Positive	Low	Local	Long-Term	Reversible	Low-High
snowshoe hare	Negative	Low	Local	Long-Term	Reversible	Low-High
black bear	Positive	High	Local-Regional	Long-Term	Reversible	Low-High
beaver	Negative	Low	Local	Long-Term	Reversible	Low-High
fisher	Positive	Low	Local-Regional	Long-Term	Reversible	Low-High
dabbling ducks	Positive	High	Local-Regional	Long-Term	Reversible	Low-High
ruffed grouse	Positive	Moderate	Local	Long-Term	Reversible	Low-High
Cape May warbler	Positive	High	Local	Long-Term	Reversible	Low-High
western tanager	Positive	High	Local	Long-Term	Reversible	Low-High
pileated woodpecker	Positive	High	Local	Long-Term	Reversible	Low-High
great gray owl	Positive	Moderate	Local	Long-Term	Reversible	Low-High

1 Changes from baseline conditions due to reclamation.

Attachment 5 (cont'd)

Table E11-19 Summary of Wildlife Impacts [1] and Degrees of Concern

Key Question	KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Degree of Concern
W-1	moose	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	red-backed vole	Negative	High	Local	Long-Term	Reversible	Low-High	High
	snowshoe hare	Negative	High	Local	Long-Term	Reversible	Low-High	High
	black bear	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	beaver	Negative	High	Local	Long-Term	Reversible	Low-High	High
	fisher	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	dabbling ducks	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	ruffed grouse	Negative	High	Local	Long-Term	Reversible	Low-High	High
	Cape May warbler	Negative	High	Local	Long-Term	Reversible	Low-High	High
	western tanager	Negative	High	Local	Long-Term	Reversible	Low-High	High
	pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Low-High	High
	great gray owl	Negative	High	Local	Long-Term	Reversible	Low-High	High
W-2	all	Negative	Low	Local	Long-Term	Reversible	Medium	Low
W-3	all	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable	Negligible
W-4	all	Negative	Low	Local	Long-Term	Reversible	Medium	Low
W-5	moose	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	red-backed vole	Negative	High	Local	Long-Term	Reversible	Low-High	High
	snowshoe hare	Negative	High	Local	Long-Term	Reversible	Low-High	High
	black bear	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	beaver	Negative	High	Local	Long-Term	Reversible	Low-High	High
	fisher	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	dabbling ducks	Negative	High	Local-Reg.	Long-Term	Reversible	Low-High	High
	ruffed grouse	Negative	High	Local	Long-Term	Reversible	Low-High	High
	Cape May warbler	Negative	High	Local	Long-Term	Reversible	Low-High	High
	western tanager	Negative	High	Local	Long-Term	Reversible	Low-High	High
	pileated woodpecker	Negative	High	Local	Long-Term	Reversible	Low-High	High
	great gray owl	Negative	High	Local	Long-Term	Reversible	Low-High	High
W-6	moose	Positive	Low	Local-Reg.	Long-Term	Reversible	Low-High	Low-Moderate (+)
	red-backed vole	Positive	Low	Local	Long-Term	Reversible	Low-High	Low (+)
	snowshoe hare	Negative	Low	Local	Long-Term	Reversible	Low-High	Low (-)
	black bear	Positive	High	Local-Reg.	Long-Term	Reversible	Low-High	Moderate-High (+)
	beaver	Negative	Low	Local	Long-Term	Reversible	Low-High	Low (-)
	fisher	Positive	Low	Local-Reg.	Long-Term	Reversible	Low-High	Low-Moderate (+)

Attachment 5 (cont'd)

Key Question	KIR	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Degree of Concern
	dabbling ducks	Positive	High	Local-Reg.	Long-Term	Reversible	Low-High	Moderate-High (+)
	ruffed grouse	Positive	Moderate	Local	Long-Term	Reversible	Low-High	Moderate (+)
	Cape May warbler	Positive	High	Local	Long-Term	Reversible	Low-High	High (+)
	western tanager	Positive	High	Local	Long-Term	Reversible	Low-High	High (+)
	pileated woodpecker	Positive	High	Local	Long-Term	Reversible	Low-High	High (+)
	great gray owl	Positive	Moderate	Local	Long-Term	Reversible	Low-High	Moderate (+)
W-7	all	Negative	Low	Local	Long-Term	Reversible	Medium	Low
W-8	moose	Positive	Low	Local-Reg.	Long-Term	Reversible	Low-High	Low-Moderate (+)
	red-backed vole	Positive	Low	Local	Long-Term	Reversible	Low-High	Low (+)
	snowshoe hare	Negative	Low	Local	Long-Term	Reversible	Low-High	Low (-)
	black bear	Positive	High	Local-Reg.	Long-Term	Reversible	Low-High	Moderate-High (+)
	beaver	Negative	Low	Local	Long-Term	Reversible	Low-High	Low (-)
	fisher	Positive	Low	Local-Reg.	Long-Term	Reversible	Low-High	Low-Moderate (+)
	dabbling ducks	Positive	High	Local-Reg.	Long-Term	Reversible	Low-High	Moderate-High (+)
	ruffed grouse	Positive	Moderate	Local	Long-Term	Reversible	Low-High	Moderate (+)
	Cape May warbler	Positive	High	Local	Long-Term	Reversible	Low-High	High (+)
	western tanager	Positive	High	Local	Long-Term	Reversible	Low-High	High (+)
	pileated woodpecker	Positive	High	Local	Long-Term	Reversible	Low-High	High (+)
	great gray owl	Positive	Moderate	Local	Long-Term	Reversible	Low-High	Moderate (+)

1 Note: Questions W-1 and W-5 consider all mitigation except reclamation; Questions W-6 and W-8 consider all mitigation and reclamation, and compare impacts relative to baseline conditions.

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Attachment 6

KOMEX INTERNATIONAL LIMITED
SUSAN LECLERC

DATE : November 10, 1997
CHEMEX PROJECT NO.: KOME010-0501-97-05554
CLIENT REFERENCE : PIT
CLIENT JOB NO. : PROJ.#4712

Analytical Data Reviewed By : Henry

QA/QC Reviewed By : H. Maxwell

The above signatures indicate that the individuals identified have reviewed the enclosed documents. The analytical results contained in this report relate only to the samples received and tested by this laboratory. If you have questions regarding this report please contact your Customer Service Representative or Dr. Robert Swingle, Manager, Technical Operations, Calgary or Dr. Ramamoorthy, Manager, Technical Operations, Edmonton.

NOTE : Soil samples and water samples (for stable parameters) will be retained for a period of 60 days after completion of analysis.
Retention beyond this period can be arranged for a fee.

MAXXAM Analytics is accredited by both the Canadian Association for Environmental Analytical Laboratories and the Standards Council of Canada for specific parameters registered with the Association and the Council.

Maxxam Analytics

Attachment 6 (cont'd)

FILE NO.: 1001-97-05554

Date : Nov 06, 1997

Company Name : KOMEX INTERNATIONAL LIMITED
Attention : ROB ARMSTRONG

Project ID : 4712

Client ID :
Chemex ID : 97-05554-MB
Date Sampled :
Date Received :

Date Extracted : Nov 03, 1997
Date Analyzed : Nov 05, 1997
Matrix : water
Dilution Factor : 1

Polyaromatic Hydrocarbons by GC/MSD (US EPA SW-846 Method 8270 Modified)

Parameter	Result	Unit	RDL	MDL
Naphthalene	< 0.050	µg/L	0.10	0.050
Acenaphthylene	< 0.050	µg/L	0.10	0.050
Acenaphthene	< 0.050	µg/L	0.10	0.050
Fluorene	< 0.050	µg/L	0.10	0.050
Phenanthrene	< 0.050	µg/L	0.10	0.050
Anthracene	< 0.050	µg/L	0.10	0.050
Acridine	< 0.50	µg/L	1.0	0.50
Fluoranthene	< 0.050	µg/L	0.10	0.050
Pyrene	< 0.050	µg/L	0.10	0.050
Benzo[c]phenanthrene	< 0.050	µg/L	0.10	0.050
Benzo[a]anthracene	< 0.050	µg/L	0.10	0.050
Chrysene	< 0.050	µg/L	0.10	0.050
7,12-Dimethylbenz[a]anthrace	< 0.50	µg/L	1.0	0.50
Benzo[b&j]fluoranthene	< 0.050	µg/L	0.10	0.050
Benzo[k]fluoranthene	< 0.050	µg/L	0.10	0.050
3-Methylcholanthrene	< 0.050	µg/L	0.10	0.050
Benzo[a]pyrene	< 0.050	µg/L	0.10	0.050
Indeno[1,2,3-cd]pyrene	< 0.050	µg/L	0.10	0.050
Dibenzo[a,h]anthracene	< 0.050	µg/L	0.10	0.050
Benzo[g,h,i]perylene	< 0.050	µg/L	0.10	0.050
Dibenzo[a,h]pyrene	< 0.10	µg/L	0.20	0.10
Dibenzo[a,i]pyrene	< 0.10	µg/L	0.20	0.10
Dibenzo[a,l]pyrene	< 0.10	µg/L	0.20	0.10

Surrogates	% Recovery	Limits	FLAG
Nitrobenzene-d5	65.4	35 - 114	Pass
2-Fluorobiphenyl	63.2	43 - 116	Pass
p-Terphenyl-d14	92.8	33 - 141	Pass

NA - Denotes compound not analyzed
MDL - Method Detection Level
RDL - Reliable Detection Level (as per CCME guidelines 2 X MDL)

Note : Bracketed results denote concentrations which fall between the MDL and RDL. As per CCME guidelines confidence levels for the bracketed values are reduced.

Comments : All samples have been corrected for blank values.

Maxxam Analytics

Attachment 6 (cont'd)

FILE NO.: 1001-97-05554

Date : Nov 06, 1997

Company Name : KOMEX INTERNATIONAL LIMITED   Project ID : 4712
Attention : ROB ARMSTRONG

Client ID :   Date Extracted : Nov 03, 1997
Chemex ID : MB SPIKE   Date Analyzed : Nov 05, 1997
Date Sampled :   Matrix : water
Date Received :   Dilution Factor : 1

Polyaromatic Hydrocarbons by GC/MSD (US EPA SW-846 Method 8270 Modified)

Parameter	% Recovery	Limits	FLAG
Acenaphthene	77.8	43 - 118	Pass
Pyrene	118.0	26 - 127	Pass

Surrogates	% Recovery	Limits	FLAG
Nitrobenzene-d5	69.2	35 - 114	Pass
2-Fluorobiphenyl	62.7	43 - 116	Pass
p-Terphenyl-d14	91.1	33 - 141	Pass

NA - Denotes compound not analyzed
MDL - Method Detection Level
RDL - Reliable Detection Level (as per CCME guidelines 2 X MDL)

Note : Bracketed results denote concentrations which fall between the MDL and RDL. As per CCME guidelines confidence levels for the bracketed values are reduced.

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Attachment 6 (cont'd)

KOMEX INTERNATIONAL LIMITED
ATTENTION : SUSAN LECLERC

PIT
PROJ.#4712

Sample Description : PIT
Sample Date & Time : 30-10-97
Sampled By : RCA
Sample Type : GRAB
Sample Received Date: October 31. 1997
Sample Station Code :

Chemex Worksheet Number : 97-05554-1
Chemex Project Number : KOME010-0501
Sample Access :
Sample Matrix : WATER
Report Date : November 10. 1997
Analysis Date : November 6. 1997

PARAMETER DESCRIPTION	ENVIRODAT CODE	UNITS		RESULTS	DETECTION LIMIT	MILLI EQUIVALENTS
Cadmium - Total (ICP-MS)	102004	mg/L	<	0.0002	0.0002	
Chromium - Total (ICP-AES)	100777	mg/L		0.008	0.002	
Cobalt - Total (ICP-MS)	102005	mg/L	<	0.0003	0.0003	
Copper - Total (ICP-AES)	100765	mg/L		0.007	0.001	
Iron - Total (ICP-AES)	100776	mg/L		0.19	0.01	
Iron - Dissolved (ICP-AES)	102090	mg/L		0.01	0.01	
Lead - Total (ICP-MS)	102001	mg/L		0.0013	0.0003	
Lithium - Total (ICP-AES)	100768	mg/L		0.096	0.001	
Manganese - Total (ICP-AES)	100775	mg/L		0.072	0.001	
Manganese - Dissolved (ICP-AES)	102089	mg/L		0.032	0.001	
Mercury - Total (CVAA)	080011	ug/L	<	0.05	0.05	
Molybdenum - Total (ICP-AES)	100760	mg/L	<	0.003	0.003	
Nickel - Total (ICP-MS)	102006	mg/L		0.0081	0.0005	
Phosphorus - Total (ICP-AES)	100754	mg/L	<	0.1	0.1	
Silver - Total (ICP-MS)	102000	mg/L		0.0014	0.0001	
Strontium - Total (ICP-AES)	100752	mg/L		0.486	0.002	
Titanium - Total (ICP-AES)	100769	mg/L	<	0.003	0.003	
Uranium - Total (ICP-MS)	101990	mg/L		0.0034	0.0004	
Vanadium - Total (ICP-AES)	100758	mg/L		0.009	0.002	
Zinc - Total (ICP-AES)	100764	mg/L		0.008	0.001	
Ion Balance	000111	Balance		0.94	0.01	

Maxxam Analytics

Attachment 6 (cont'd)

KOMEX INTERNATIONAL LIMITED
ATTENTION : SUSAN LECLERC

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Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 FAX (403) 291-9468
Edmonton: 9331 - 48th Street T6B 2R4 Telephone (403) 468-3500 FAX (403) 466-3332

PIT
PROJ.#4712

Sample Description : PIT
Sample Date & Time : 30-10-97
Sampled By : RCA
Sample Type : GRAB
Sample Received Date: October 31. 1997
Sample Station Code :

Chemex Worksheet Number : 97-05554-1
Chemex Project Number : KOME010-0501
Sample Access :
Sample Matrix : WATER
Report Date : November 10. 1997
Analysis Date : November 6. 1997

PARAMETER DESCRIPTION	ENVIRODAT CODE	UNITS		RESULTS	DETECTION LIMIT	MILLI EQUIVALENTS
Calcium - (ICP) Total	020005	mg/L		39.5	0.1	1.921
Calcium - (ICP) Dissolved	020111	mg/L		35.2	0.1	1.756
Magnesium - (ICP) Total	012005	mg/L		32.9	0.1	2.708
Magnesium - (ICP) Dissolved	012111	mg/L		30.9	0.1	2.543
Sodium - (ICP) Total	011005	mg/L		375.	0.1	16.313
Sodium - (ICP) Dissolved	011111	mg/L		353.	0.1	15.356
Potassium -(ICP) Total	100774	mg/L		7.19	0.2	0.184
Potassium -(ICP) Dissolved	019111	mg/L		6.76	0.2	0.173
Chloride - Dissolved	17203	mg/L		342.	0.5	9.644
Sulphate - (IC) Dissolved	016309	mg/L		103.	0.1	2.142
PP Alkalinity (as CaCO3)	010151	mg/L	<	0.1	0.1	
Total Alkalinity (as CaCO3)	010111	mg/L		463.	0.5	
pH	010301	Units		8.16	0.01	
Carbonate	006301	mg/L	<	0.5	0.5	
Bicarbonate	006201	mg/L		570.	0.5	9.356
Total Hardness (as CaCO3)	010602	mg/L		215.	0.5	
Hydroxide	008501	mg/L	<	0.5	0.5	
Silicon - Total (ICP)	100757	mg/L		3.91	0.02	
Fluoride	009105	mg/L		0.65	0.05	
Specific Conductance	002041	uS/cm		2185.	0.02	
Phenols	006537	mg/L	<	0.001	0.001	
Total Dissolved Solids	000201	mg/L		1156.	1.	
Total Kjeldahl Nitrogen	007015	mg/L		0.48	0.05	
Nitrite Nitrogen as N	007206	mg/L		0.011	0.003	
Nitrate Nitrogen as N	007301	mg/L		0.005	0.003	0.000
Nitrite plus Nitrate Nitrogen as N	007110	mg/L		0.016	0.003	
Sulphur - (ICP) - Total	100755	mg/L		32.9	0.2	
Total Filterable Residue (TDS)	010451	mg/L		1288.	1.	
Non-Filterable Residue (TSS)	010401	mg/L		1.0	0.4	
Aluminum - Total (ICP-AES)	100761	mg/L		0.04	0.01	
Barium - Total (ICP-AES)	100753	mg/L		0.07	0.01	
Beryllium - Total (ICP-AES)	100762	mg/L	<	0.001	0.001	
Boron - Total (ICP-AES)	100773	mg/L		0.70	0.01	

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Attachment 6 (cont'd)

FILE NO.: 1001-97-05554

Date : Nov 06, 1997

Company Name : KOMEX INTERNATIONAL LIMITED
Attention : ROB ARMSTRONG

Project ID : 4712

Client ID : PIT
Chemex ID : 97-05554-01
Date Sampled : Oct 30, 1997
Date Received : Oct 31, 1997

Date Extracted : Nov 03, 1997
Date Analyzed : Nov 05, 1997
Matrix : water
Dilution Factor : 1

Polyaromatic Hydrocarbons by GC/MSD (US EPA SW-846 Method 8270 Modified)

Parameter	Result	Unit	RDL	MDL
Naphthalene	< 0.050	µg/L	0.10	0.050
Acenaphthylene	< 0.050	µg/L	0.10	0.050
Acenaphthene	< 0.050	µg/L	0.10	0.050
Fluorene	< 0.050	µg/L	0.10	0.050
Phenanthrene	< 0.050	µg/L	0.10	0.050
Anthracene	< 0.050	µg/L	0.10	0.050
Acridine	< 0.50	µg/L	1.0	0.50
Fluoranthene	< 0.050	µg/L	0.10	0.050
Pyrene	< 0.050	µg/L	0.10	0.050
Benzo[c]phenanthrene	< 0.050	µg/L	0.10	0.050
Benzo[a]anthracene	< 0.050	µg/L	0.10	0.050
Chrysene	< 0.050	µg/L	0.10	0.050
7,12-Dimethylbenz[a]anthrace	< 0.50	µg/L	1.0	0.50
Benzo[b&j]fluoranthene	< 0.050	µg/L	0.10	0.050
Benzo[k]fluoranthene	< 0.050	µg/L	0.10	0.050
3-Methylcholanthrene	< 0.050	µg/L	0.10	0.050
Benzo[a]pyrene	< 0.050	µg/L	0.10	0.050
Indeno[1,2,3-cd]pyrene	< 0.050	µg/L	0.10	0.050
Dibenzo[a,h]anthracene	< 0.050	µg/L	0.10	0.050
Benzo[g,h,i]perylene	< 0.050	µg/L	0.10	0.050
Dibenzo[a,h]pyrene	< 0.10	µg/L	0.20	0.10
Dibenzo[a,i]pyrene	< 0.10	µg/L	0.20	0.10
Dibenzo[a,l]pyrene	< 0.10	µg/L	0.20	0.10

Surrogates	% Recovery	Limits	FLAG
Nitrobenzene-d5	60.3	35 - 114	Pass
2-Fluorobiphenyl	64.6	43 - 116	Pass
p-Terphenyl-d14	89.3	33 - 141	Pass

NA - Denotes compound not analyzed
MDL - Method Detection Level
RDL - Reliable Detection Level (as per CCME guidelines 2 X MDL)

Note : Bracketed results denote concentrations which fall between the MDL and RDL. As per CCME guidelines confidence levels for the bracketed values are reduced.

Comments : All samples have been corrected for blank values.

Attachment 7

Dissolved Oxygen Concentrations in the Muskeg River Basin

Muskeg River		Jackpine Creek		East Jackpine Creek		Shelley Creek		Muskeg Creek		Stanley Creek		Wapasu Creek	
Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)
Summary Stats													
Minimum	0	Minimum	3.3	Minimum	7.2	Minimum	6.1	Minimum	1.8	Minimum	1.6	Minimum	4.7
Median	8.2	Median	8.6	Median	9.1	Median	6.5	Median	6.8	Median	5.8	Median	6.6
Maximum	13.6	Maximum	14.4	Maximum	14.4	Maximum	12.2	Maximum	13.4	Maximum	9.3	Maximum	10.0
Count	91	Count	48	Count	7	Count	4	Count	14	Count	6	Count	4
Data													
4-May-78	4	8-Sep-76	8	8-Sep-76	9.1	17-May-77	6.6	4-Oct-77	8.7	10-Sep-76	9.3	10-Sep-76	5
6-Jul-81	2	17-May-77	10	11-Oct-77	14.4	20-Jul-77	6.3	9-Sep-76	9.6	18-May-77	6.1	17-May-77	10
6-Oct-80	3.9	20-Jul-77	6.9	17-May-77	11.6	21-Jun-77	6.1	19-Jul-77	6.2	20-Jul-77	7.1	18-Jul-77	4.7
8-Jun-81	0	21-Jun-77	6.9	20-Jul-77	7.2	25-Apr-77	12.2	21-Jun-77	4.7	21-Jun-77	3.8	25-Apr-77	8.1
10-Sep-76	7.6	25-Apr-77	6	21-Jun-77	7.5			19-Jul-77	6.7	26-Apr-77	5.4		
11-May-81	6.4	8-Sep-76	12	25-Apr-77	12.2			21-Jun-77	1.8	29-Jul-76	1.6		
13-Jul-77	6.2	16-May-77	10.8	28-Jul-76	7.6			25-Apr-77	3.1				
17-May-77	7.6	18-Jul-77	7.6					10-Apr-78	10.6				
18-Jul-77	6.2	20-Jun-77	8.5					14-Sep-77	8.6				
24-Jun-77	4.1	25-Apr-77	12					16-Aug-77	2.4				
26-Apr-77	8.4	27-Jul-76	10.8					17-May-77	9.4				
30-Mar-81	4.6	2-Mar-81	4.7					18-Jul-77	6.9				
31-Aug-81	3.7	3-May-78	13					20-Jun-77	6.3				
2-Mar-81	1.8	3-Nov-80	5					26-Apr-77	13.4				
3-May-78	11.8	4-Aug-80	7.8										
3-Nov-80	7.5	4-Oct-77	8.3										
4-Aug-80	7.7	4-Oct-78	9.8										
4-Oct-77	10.4	5-May-80	8.3										
4-Oct-78	8.6	5-Jun-78	5.2										
5-May-80	7.9	5-Oct-81	6.3										
5-Jun-78	5.3	6-Apr-78	7.5										
5-Oct-81	9.7	6-Jul-81	5.7										
6-Apr-78	7.4	6-Oct-80	9.4										
6-Jul-81	10.4	7-Sep-76	11.6										
6-Oct-80	7	7-Sep-78	8.6										
7-Sep-76	9.5	8-Jun-81	7.7										
7-Sep-78	7.8	8-Jul-80	5.4										
8-Jun-81	9.35	8-Sep-80	10.5										
8-Jul-80	8.2	9-Jun-80	9.1										
8-Sep-80	9.3	10-Jul-78	9.9										
9-Jun-80	9.3	11-May-81	11.4										
9-Jul-79	7.75	13-Jul-77	7										
10-Jul-78	9.9	13-Sep-77	9.8										
11-May-81	10.6	14-Apr-80	5.3										
11-Jun-79	7.6	15-Aug-78	8.8										
13-Aug-79	9	16-May-77	9.1										
13-Sep-77	10	16-Aug-77	12										
14-Apr-80	6.2	18-Apr-77	14.4										

Attachment 7 (cont'd)

Dissolved Oxygen Concentrations in the Muskeg River Basin

Muskeg River		Jackpine Creek		East Jackpine Creek		Shelley Creek		Muskeg Creek		Stanley Creek		Wapasu Creek	
Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)
15-Aug-78	9.1	18-Jul-77	5.2										
15-Oct-79	5	20-Sep-78	9.35										
16-May-77	9.5	21-Jun-78	9.5										
16-Aug-77	11.8	22-Jun-77	6.5										
17-Sep-79	8.1	26-Jan-81	3.3										
18-Jul-77	5.2	26-Oct-78	12.6										
20-Jun-77	6.3	26-Oct-81	12										
20-Jul-78	9.6	27-Jul-76	9.2										
20-Sep-78	8.15	30-Mar-81	7.5										
21-Jun-78	9.7	31-Aug-81	6.7										
24-Jul-78	8.3												
24-Jul-78	8.3												
24-Jul-78	8.3												
24-Jul-78	8.3												
24-Jul-78	8.3												
24-Jul-78	8.3												
24-Jul-78	8.3												
26-Jan-81	5.4												
26-Oct-78	13.6												
26-Oct-81	12												
27-Jul-76	9.1												
28-Aug-78	8.6												
28-Aug-78	8.6												
28-Aug-78	8.6												
28-Aug-78	8.6												
28-Aug-78	8.6												
28-Aug-78	8.6												
30-Mar-81	8												
31-Aug-81	8.2												
20-Aug-76	8												
22-Mar-78	8.1												
7-Mar-91	6.47												
9-Mar-89	5.9												
10-Mar-94	5.14												
10-Mar-95	1.9												
11-Mar-93	4.11												
14-Feb-89	11.1												
15-Mar-90	11.5												
26-Feb-92	9.2												
7-Mar-91	5.71												
7-Mar-91	5.62												
9-Mar-89	6.08												
9-Mar-89	5.87												
10-Mar-94	4.74												

Dissolved Oxygen Concentrations in the Muskeg River Basin

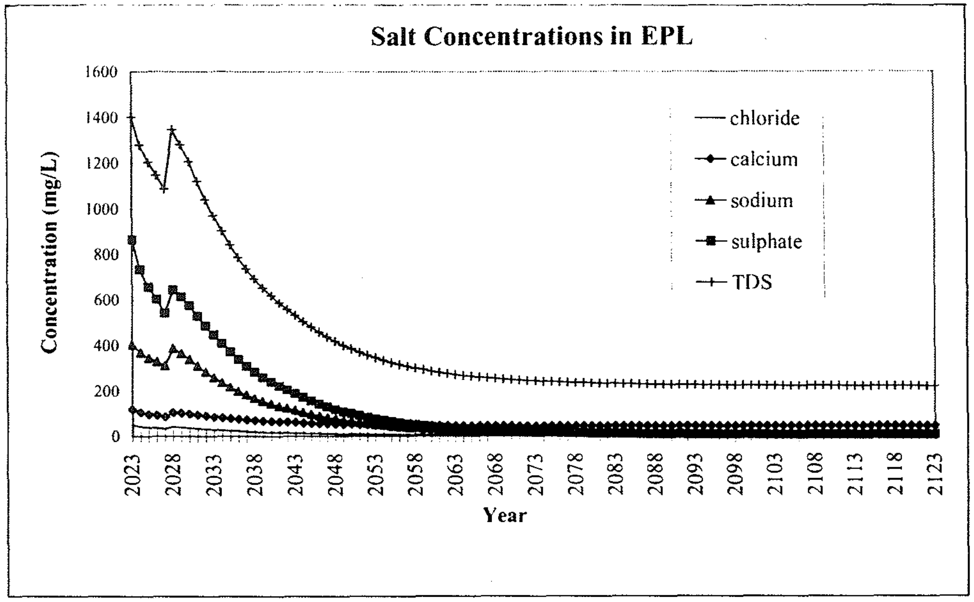
Muskeg River		Jackpine Creek		East Jackpine Creek		Shelley Creek		Muskeg Creek		Stanley Creek		Wapasu Creek	
Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)	Date	Level (mg/L)
10-Mar-94	4.78												
10-Mar-95	1.61												
11-Mar-93	4.03												
11-Mar-93	3.99												
14-Feb-89	10.49												
14-Feb-89	10.67												
15-Mar-90	11.23												
26-Feb-92	9.13												
26-Feb-92	9.36												

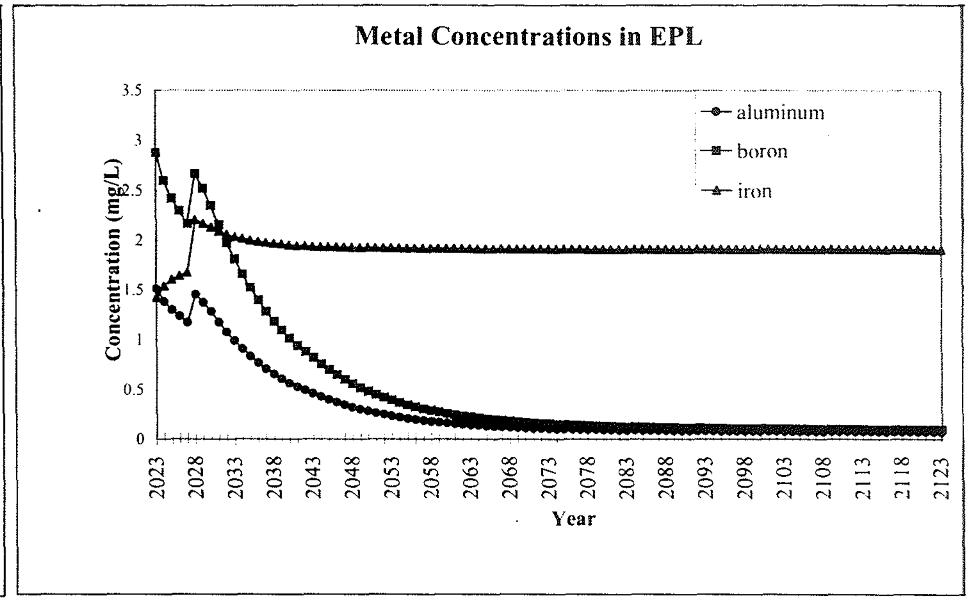
Attachment 8

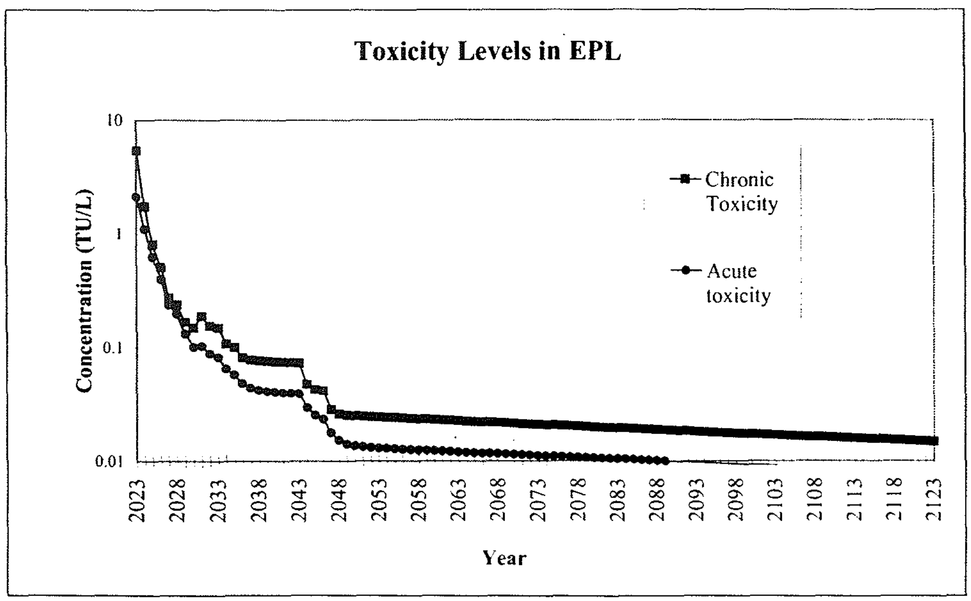
Substance Concentrations in the End Pit Lake over time, from lake formation through discharge to the Muskeg River.

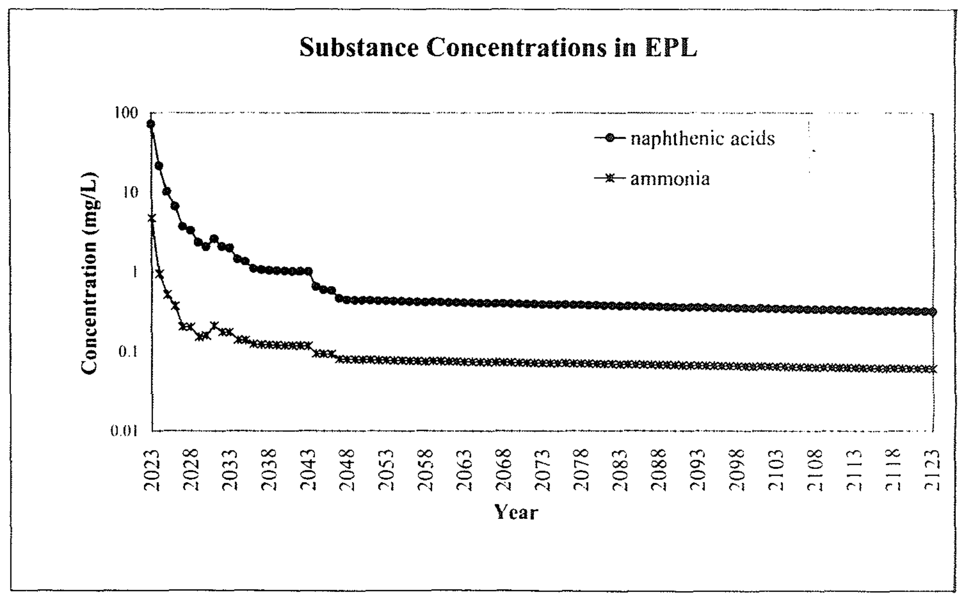
Muskeg River Mine End Pit Lake Model Predictions from Initial Filling to Far Future

Attachment 8 (cont'd)









Attachment 8 (cont'd)

Substance concentrations in the Muskeg River Mine EPL over time

	Year															
	filling of the EPL			EPL discharging to Muskeg (or Athabasca) River												
Substance mg/L)	2023	2025	2027	2029	2033	2035	2040	2045	2050	2060	2070	2080	2090	2100	2110	2120
Aluminum - Total	1.51	1.30	1.17	1.37	0.99	0.84	0.57	0.40	0.28	0.16	0.11	0.09	0.09	0.08	0.08	0.08
Ammonia - Total	4.81	0.53	0.21	0.15	0.17	0.14	0.12	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.06	0.06
Antimony - Total	0.0012	0.0009	0.0008	0.0008	0.0006	0.0005	0.0003	0.0002	0.0001	5.3E-05	2.2E-05	9.2E-06	4.0E-06	1.8E-06	8.0E-07	3.7E-07
Arsenic - Total	0.006	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Barium - Total	0.134	0.120	0.111	0.134	0.107	0.096	0.078	0.067	0.059	0.051	0.048	0.047	0.046	0.046	0.046	0.046
Benzo(a)anthracene grp	0.0011	0.0005	0.0002	0.0002	6.9E-05	4.2E-05	1.8E-05	6.1E-06	5.9E-07	5.8E-09	5.9E-11	6.2E-13	6.6E-15	7.2E-17	8.0E-19	9.1E-21
Benzo(a)pyrene grp	0.0003	0.0001	5.7E-05	3.7E-05	1.5E-05	9.2E-06	4.1E-06	1.2E-06	6.8E-08	2.2E-10	7.5E-13	2.6E-15	9.3E-18	3.4E-20	1.2E-22	4.7E-25
Beryllium-Total	0.0044	0.0036	0.0031	0.0036	0.0026	0.0022	0.0014	0.0009	0.0006	0.0003	0.0002	0.0001	8.1E-05	6.9E-05	6.3E-05	5.9E-05
Boron - Total	2.88	2.42	2.16	2.52	1.81	1.53	1.02	0.70	0.48	0.26	0.17	0.13	0.12	0.11	0.10	0.10
Cadmium - Total	0.0053	0.0045	0.0041	0.0049	0.0036	0.0031	0.0022	0.0016	0.0012	0.0008	0.0007	0.0006	0.0006	0.0005	0.0005	0.0005
Calcium	118.5	98.6	87.0	103.5	86.8	79.6	66.7	58.6	53.3	48.2	46.2	45.4	45.1	44.9	44.9	44.9
Chloride	49.0	39.7	34.5	39.9	29.7	25.4	17.7	13.0	9.7	6.4	5.1	4.5	4.3	4.2	4.1	4.1
Chromium - Total	0.016	0.013	0.011	0.013	0.010	0.009	0.007	0.006	0.005	0.004	0.003	0.003	0.003	0.003	0.003	0.003
Conductivity	1919	1662	1511	1788	1359	1186	882	695	566	434	382	360	350	345	342	340
Copper - Total	0.016	0.013	0.011	0.013	0.010	0.008	0.006	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
Dissolved Organic Carbon	55.3	49.8	46.3	55.8	45.0	40.7	33.1	28.6	25.5	22.3	21.0	20.5	20.3	20.1	20.1	20.0
Iron - Total	1.42	1.61	1.68	2.16	2.03	2.00	1.96	1.93	1.93	1.92	1.92	1.91	1.91	1.91	1.91	1.91
Lead - Total	0.014	0.011	0.009	0.010	0.008	0.007	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Magnesium	22.6	19.7	18.0	21.7	18.6	17.2	14.9	13.5	12.6	11.7	11.3	11.2	11.1	11.1	11.1	11.1
Manganese - Total	0.13	0.16	0.17	0.23	0.26	0.27	0.29	0.30	0.31	0.33	0.33	0.33	0.33	0.34	0.34	0.34
Mercury - Total	5.0E-05	4.9E-05	4.8E-05	6.3E-05	7.0E-05	7.2E-05	7.7E-05	8.0E-05	8.3E-05	8.6E-05	8.7E-05	8.7E-05	8.8E-05	8.8E-05	8.8E-05	8.8E-05
Molybdenum - Total	0.96	0.72	0.60	0.67	0.49	0.41	0.26	0.17	0.10	0.04	0.02	0.008	0.003	0.002	0.001	0.001
Naphthenic Acids	72.8	10.1	3.69	2.32	2.00	1.35	1.03	0.60	0.44	0.42	0.40	0.38	0.36	0.35	0.33	0.32
Nickel - Total	0.02	0.0152	0.0126	0.0143	0.0106	0.0089	0.0060	0.0041	0.0028	0.0016	0.0011	0.0009	0.0008	0.0008	0.0008	0.0008
Nitrate	0.10	0.13	0.14	0.18	0.16	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Phenolics - Total	0.01	0.009	0.008	0.009	0.006	0.005	0.003	0.002	0.001	0.0007	0.0004	0.0002	0.0002	0.0001	0.0001	0.0001
Selenium - Total	0.002	0.002	0.002	0.002	0.001	0.001	0.0007	0.0004	0.0003	0.0001	5.2E-05	2.6E-05	1.5E-05	9.9E-06	7.6E-06	6.5E-06
Silver - Total	0.001	0.001	0.0008	0.0009	0.0007	0.0006	0.0004	0.0002	0.0001	5.9E-05	2.4E-05	1.0E-05	4.4E-06	2.0E-06	8.9E-07	4.1E-07
Sodium	403	346	314	367	261	219	144	98.5	66.3	33.4	20.2	14.7	12.1	10.7	9.9	9.3
Strontium	1.48	1.17	0.99	1.14	0.85	0.73	0.51	0.37	0.27	0.18	0.14	0.12	0.12	0.12	0.11	0.11
Sulphate	863	656	542	614	447	373	241	157	100	43	21	12	8	6	6	5
Total Dissolved Solids	1403	1204	1088	1283	970	843	619	482	386	290	251	235	228	224	222	221
Total PAHs	0.022	0.017	0.014	0.016	0.011	0.010	0.006	0.004	0.003	0.001	0.0005	0.0002	0.0001	0.0001	0.0001	0.0001
Toxicity - acute	2.11	0.62	0.24	0.13	0.082	0.057	0.040	0.025	0.014	0.012	0.011	0.011	0.010	0.009	0.009	0.008
Toxicity - chronic	5.43	0.80	0.27	0.17	0.15	0.10	0.075	0.043	0.025	0.023	0.021	0.020	0.018	0.017	0.016	0.015
Vanadium - Total	0.12	0.09	0.07	0.08	0.06	0.05	0.03	0.02	0.01	0.006	0.003	0.002	0.001	0.001	0.001	0.001
Zinc - Total	0.057	0.045	0.038	0.045	0.037	0.033	0.027	0.023	0.020	0.018	0.016	0.016	0.016	0.016	0.016	0.016

F1.2.2 Effects of Baseline Air Quality on Human Health

F1.2.2.1 Alberta Oil Sands Community Exposure and Health Effects Assessment Program

The Alberta Oil Sands Community and Health Effects Assessment Program (AOSCEHEAP) is a joint industry, government and community initiative to collect high quality exposure data over the time frame of the oil sands industry which will enable a defensible assessment of environmental influences to human health. Presently, this initiative is specifically focused on air quality data for exposure assessment of regional residents. The program is in the early stages and so far the efforts have addressed the data quality objectives, sampling methods and equipment needed to facilitate the ultimate goal of exposure assessment.

To this end, AOSCEHEAP has reported on a review of the state-of-the-practice personal air monitoring devices, and has conducted a brief pilot study to demonstrate the feasibility of the preferred sampling devices (AOSCEHEAP 1997). The study suggests the devices are, for the most part, practical for implementation in a larger scale study. However, some data suggest that the personal air monitoring devices may not reflect the ambient air quality, but rather they may reflect influences from brief encounters with micro-environments, such as the exhaust plume from a car (e.g., nitrogen dioxide). Results of the chemical analysis indicate that levels of exposure can vary considerably amongst and within individuals, and chemical levels will vary within a given day. This suggests that multiple measures should be taken to accurately determine the level of exposure to individuals and populations. The pilot study indicated no evidence of detectable personal exposure to ozone. The indoor and personal measures of nitrogen dioxide were greater than outdoor ambient conditions. The highest level of sulfur dioxide exposure was encountered outside and these levels appear to be influencing the indoor exposure as well. Some of the volatile organic carbon compounds were almost non-detectable, while others were not only detectable, but highly associated with other chemicals of their class. Therefore, when devising a sampling program for the main study, careful consideration should be given to the selection of volatile organic carbons to analyze.

The limited data generated from the pilot study is not suitable for conducting exposure assessment for health risk assessment, although the full scale study is anticipated to provide this capability. The main study, which constitutes the second phase of the program, is intended to produce baseline population exposure and health outcome data. This phase is currently in progress and involves a population exposure assessment survey and a population health assessment. This is accomplished through use of a questionnaire to characterize various parameters/activities needed to explore potential associations with field measurements of personal and ambient exposure conditions. As part of the health assessment, several measures of biomarkers are included in the study design, to provide physiologically-based information respecting both exposure and health effects. Biomarkers of exposure include blood and urine analyses of organic and inorganic chemicals. Biomarkers of health effects include assays using blood, urine and lung tissue for endpoints of mutagenicity, activation of detoxification pathways, macromolecules adduct formation, chromosomal abberrations, oncogene expression, immune function and respiratory function. In addition, assessment of neurobehavioural status is included as an effect endpoint. Further details of this study design are available from the AOSCEHEAP technical approach document (AOSCEHEAP 1995). Results of the main study were not available during preparation of this EIA; however, the report is anticipated in the early summer of 1998.

DEPARTMENT OF FISHERIES AND OCEANS

OVERVIEW

As part of Shell's commitment to ensuring meaningful consultation with stakeholders and regulators, Shell has been meeting with representatives of the Canadian Environmental Assessment Agency (CEAA), Department of Fisheries and Oceans (DFO), and other federal agencies to provide more information about the Muskeg River Mine Project and to understand and resolve their potential issues.

Shell has submitted additional information with this filing to address a number of concerns identified by the Department of Fisheries and Oceans and the Canadian Coast Guard which potentially impact their regulatory mandate.

In addition, Shell is working with Environment Canada, the Department of Indian and Northern Affairs (DIAND) and Parks Canada to address their comments related to the proposed project. Shell is treating these comments seriously and has met with Environment Canada on June 19th and will meet with DIAND in July to fully understand the comments raised and work towards resolving the issues.

Shell intends to ensure that all of the comments from the federal authorities on the Muskeg River Mine Project are addressed. In addition to the responses to DFO and Coast Guard contained in this supplemental information, Shell will be filing additional information and responses to the comments from Environment Canada, DIAND and Parks Canada in an update on its "Public Consultation Process" in mid-July, 1998.

MUSKEG RIVER MINE PROJECT
Information Request

EUB No.	Exhibit No.
Information Requested By: Department of Fisheries and Oceans	
Date of I.R. May 19, 1998	

Question No. 3.1

Shell No. DFO 1

Issue **Muskeg River Crossings**

Request The proponent is requested to provide further details and information on this proposed crossing in a timely manner. The location of these crossings in an area of significant fish habitat merits careful consideration.

Response The Muskeg River crossing will be a three-span bridge. The bridge design, location, construction timing and construction techniques are described in Section 3.5 (Muskeg River Crossing) in the Project Update.

The details of the crossing of the Muskeg River by the product/diluent pipeline will be provided in the pipeline application and Conservation and Reclamation Plan.

Question No. 3.2

Shell No. DFO 2

Issue **Athabasca River Water Intake**

Request More details need to be provided on the proposed water intake from the Athabasca River along with the design criteria used to minimize potential impacts on fish and fish habitat.

Response The Athabasca River water intake, design, location and construction are described in Section 4.2 (Water Management) in the Project Update.

Question No.	**3.2**
Shell No.	**DFO 3**
Issue	**Athabasca River Water Intake**

Request

The maximum indicated instantaneous withdrawal rate of 2.5 m^3/s constitutes a significant potential for fish entrainment for the direct withdrawal option. There is also some concern that the reserve capacity of the Athabasca River may be taxed to meet the instream flow requirements for fish and fish habitat. It is not clear that the proposed withdrawal of 0.4% of mean annual, 2% of 7Q10 flows for the project assessment and 6.4% of 7Q10 for the regional development scenario constitutes a "negligible impact" as stated in the EIA. Further evidence on the cumulative impact of water withdrawals and identifiable instream flow needs for fish and fish habitat needs to be considered.

Response

It is noted in the EIA that, during operations, there would be a slight decrease in flows in the Athabasca River and that the decrease would not be expected to affect fish habitat. The maximum reduction in flows is about 2% of the 7Q10 flow. As the 7Q10 flow represents a seven-day duration low flow event that occurs with a 10-year return period, this situation reflects a worst case. As a 2% reduction in flow under this situation, which occurs very infrequently, would not be detectable or measurable, it is reasonable to conclude that there would not likely be any effect on fish habitat. Likewise, even the cumulative 6.4% of the 7Q10 would be very difficult to detect. However, the potential for increased water withdrawals from the Athabasca River to affect the instream flow needs for fish in the Athabasca River is a regional issue. Shell is committed to participating in discussions with DFO, AEP and other interested parties on this issue.

Question No.	**3.2**
Shell No.	**DFO 4**
Issue	**Athabasca River Water Intake**

Request

The alternative option for withdrawal from an area adjacent to Isadore's Lake needs to be examined to determine the potential impact on local water levels and the fish and fish habitat of Isadore's Lake.

Response

The Isadore's Lake water intake site is no longer being considered (see Section 4.2, Water Management, in the Project Update).

Question No. 3.3

Shell No. DFO 5

Issue **Habitat Displacement**

Request

The comparison of habitat associated with the project to the Regional Study Area (RSA) condition is not justified. For the cumulative effects assessment the predicted losses in forage fish habitat are stated as 1.7 % from the RSA (0.1% attributed to the project) and for the RDR the amount is 3.1% . The significance of the habitat losses of the Muskeg River basin is lost in the comparison to the RSA. It is further stated that at each stage habitat disturbed will be replaced with equivalent or better habitat. It is not clear how this can occur as there will be a lag between habitat destruction and reclamation and there is also likely to be a lag between reclamation and significant productive capability within the recreated landscape. This lag could be a very significant length of time before the release of CT waters is significantly attenuated to allow forage fish production. As such, the stated net gains of 20% and 30% for the CEA and RDR analyses may not be justified.

Response

In the impact assessment section (EIA Volume 3, Part 1, page E6-30) habitat loss from the project is compared to the Local Study Area which is the Muskeg River watershed. For the cumulative effects assessment, the Regional Study Area was used as there might be habitat loss associated with regional developments that occur outside the Muskeg River watershed (e.g., the Steepbank Mine).

Habitat loss predicted in the cumulative effects scenario includes the Muskeg River Mine (29 ha), Aurora North (52 ha) and Aurora South (124 ha) (see EIA Volume 4, page F4-24). These can be compared to the area of streams and ponds in the Muskeg River basin (about 1,671 ha, page E6-30). This represents a 12% loss of forage fish habitat in the watershed under the CEA scenario.

Forage fish habitat will be replaced concurrent (i.e., within five years) with its loss. Throughout all stages of mine development, active surface water management will be occurring. As part of the surface water management, forage fish habitat will be created within the infrastructure created to manage the surface waters. The fact that forage fish are using the habitat created in the Alsands drainage system is evidence that this approach is feasible. The end-pit lake and reclamation wetlands will not be used as compensation, as these features will not be constructed until much later in the project. Additionally, the viability of these latter features as productive fish habitat will need to be demonstrated. Shell is committed to replacing habitat concurrent with its loss and will provide a plan (the No Net Loss Plan) to demonstrate how this will be achieved.

Question No. 3.2

Shell No. DFO 6

Issue **Habitat Displacement**

Request

Both the cumulative effects assessment and the regional development review identify major increases in open water areas with increases from 464 ha to 5664 ha for the CEA and from 852 to 8534 for the RDR. What these calculations do not factor in is the production potential of the re-created water bodies as compared to the baseline condition. It is recognized that these areas largely consist of the end pit lakes and the reclaimed wetlands. The value of these recreated areas in providing, or supporting fish habitat is somewhat suspect given that these areas are primarily designed to receive and treat CT waters prior to release. As such, these areas cannot be recognized as productive fish habitat until such time as it can be demonstrated that these areas can produce self sustaining fish populations that can contribute to a fishery.

Response

Shell has not attempted to accrue credit for the end-pit lake and reclaimed wetlands as compensation for habitat loss for the Muskeg River Mine Project (see the response to DFO 7). Shell acknowledges that the productivity of the end-pit lake and reclaimed wetlands will need to be demonstrated and that these features will take time to develop into productive fish habitats.

As stated in EIA Volume 3, Part 1, page E5-35, "The intended end use for the lake is a self-sustaining, biologically productive waterbody." Although Shell is committed to meeting the expectations of stakeholders in developing the end-pit lake, it is expected that fish would be introduced to the lake at a time where they could colonize this waterbody. As this is a man-made waterbody, the physical features required by the various life stages of the target management species could be incorporated into the final configuration of this waterbody.

The ability of reclamation wetlands and end-pit lakes to support aquatic life has been, and continues to be, investigated by existing oil sands operations (EVS 1995, EVS 1996, Xu and Johnson 1996, Golder 1997, Renault and Zwiazek 1997). Further, information produced to date indicates that viable aquatic ecosystem can be established on reclamation landscapes, such as the one described in the Muskeg River Mine Project EIA.

As outlined in EIA Volume 3, Section E6.9.2, several characteristics of the lake would have to be considered if fish were introduced into the lake. Shell is a member of CONRAD, CEATAG and RAMP and will participate in research associated with end pit lakes.

See also the responses to AEP 105 to 114.

Question No. 4.1

Shell No. DFO 7

Issue **Surface Water Quantity – Water Releases**

Request

The EIA identifies changes to the flow regime and water levels of streams, ponds, lakes and wetlands within the study area. These water bodies would be affected through disturbance of the surficial and Basal aquifers, overburden dewatering , MFT transfer and seepage. Specific areas that could be affected include the Athabasca River, Muskeg River, Mills Creek and Isadore's Lake. The timing, magnitude and duration of these effects needs to be considered in light of the potential impacts on fish and fish habitat. Additionally, alternate methods of dealing with project water releases from the end pit lake needs to be explored further and should include examining other alternatives for discharging from the end pit lake.

Response

The effects of timing, magnitude and duration of changes in flows and water quality on fish habitat were assessed and the results presented in EIA Volume 3, Part 1, Section E6.5. Some of this information has been presented in greater detail in Section 7.1 (End-Pit Lake Discharge) in the Project Update. Section 7.1 also discusses the alternative method of discharging the end-pit lake water to the Athabasca River.

Question No. 4.1

Shell No. DFO 8

Issue **Surface Water Quantity – Water Releases**

Request

It is stated that reduced drainage area will result in a reduction of 23% in mean annual flows into Isadore's Lake (E4-44). The effect of this reduction has been assessed as "moderate" and arbitrarily dismissed on the basis that flow reduction is less important than flow increase in terms of consequent effects on stream geomorphic conditions. While that may be the case for stream geomorphic conditions, reduced stream flows may have a far greater consequence ultimately on the flows and levels of Isadore's Lake for sustainable fish production. Further analysis of the potential implications on fish and fish habitat of Isadore's Lake is warranted.

Response

Implications of reduced flows into Isadore's Lake on fish and fish habitat are described in EIA Volume 3, Part 1, Section E-6, Aquatic Resources, pages E6-15, 17 and 20 (see the response to DFO 36).

As noted on page E6-15, changed flows into Isadore's Lake are expected to have the effect of a less than 1 cm reduction in lake level during construction, a decrease in lake level of 3 cm early in operations, an increase in lake level later on in operations of about 5 cm in 2020, and a decrease in lake level of about 1.4 cm at closure. All of these changes represent less than a 1% change in lake level, when considered in the context of mean depth. Thus, any effects on fish or fish habitat would be very minor.

The potential effects of lake level fluctuations on northern pike spawning and egg incubation are discussed on page E6-20 of the EIA. It is concluded that the small changes in lake level are unlikely to affect, in either a positive or negative way, access to this waterbody by northern pike, or spawning and egg incubation for this species. See also the response to AEP 88.

Question No. 4.1

Shell No. DFO 9

Issue **Surface Water Quantity – Hydrology**

Request With regard to Surface Water Hydrology (D-4): This section presents the climate and hydrology data but does not discuss its significance and conclusions.

Response The purpose of the baseline hydrology study, including stream flow analysis, is to synthesize all available hydrology information and data, as well as relevant climate data, for characterizing the baseline climatic and hydrologic conditions in the LSA and RSA. The baseline data provide a reference data set for comparison with predicted or expected hydrologic conditions in the future. The comparison provides a basis for quantifying the project impacts. The baseline data were extensively used for the incremental impact analysis presented in EIA Volume 3, Part 1, Section E4, for the cumulative effects assessment in EIA Volume 4, Section F4, and for the regional development review in EIA Volume 4, Section G4.

Question No. 4.1

Shell No. DFO 10

Issue **Surface Water Quantity – Hydrology**

Request On page D4-13, it is not clear how Potential Evapotranspiration and Evaporation were derived. The stated definitions are vague, if not simplistic.

Response The EIA used the evaporation and evapotranspiration data published by AEP for Alberta, which were derived using the CRLE and CRAE models developed by F.I. Morton at the National Hydrology Research Institute.

The definitions of the relevant terms are based on the report by AEP entitled "Evaporation and Evapotranspiration in Alberta" (Bothe et. al., 1987).

Question No.	**4.1**
Shell No.	**DFO 11**
Issue	**Surface Water Quantity – Hydrology**
Request	What conclusions can be made about the stream flow analysis?
Response	See the response to DFO 9.

Question No.	**4.1**
Shell No.	**DFO 12**
Issue	**Surface Water Quantity – Hydrology**
Request	On page D4-38, several channel cross sections were used in the flood risk analysis of the Muskeg River and Jackpine Creek floodplains. However, the 10 yr. and 100 yr. floods go beyond the extents of several cross sections. Should not the cross sections extend beyond the calculated flood extent to provide an accurate estimate?
Response	The channel cross-sections were surveyed before the flood water level calculations had been completed. Therefore, the calculated 10-year and 100-year flood levels indicate flood risk limits beyond the extents of some of the surveyed cross sections. We assume that the floodplain beyond the survey extents is ineffective in conveying flood flows. This results in conservative estimates of higher flood levels. This approach results in higher safety margins and freeboard for protecting the mining facilities, because the facilities will be designed based on the conservative flood levels.

Question No.	**4.1**
Shell No.	**DFO 13**
Issue	**Surface Water Quantity – Hydrology**
Request	The flood risk zones shown on the 1:20 000 map (Fig. D4-18) do not follow the contour patterns shown. Were the flood risk zones drawn on a different base map?
Response	See the response to DFO 12.

Question No.	**4.1**
Shell No.	**DFO 14**
Issue	**Surface Water Quantity – Hydrology**
Request	(The cross sections appear in Appendix I of Golder (1997, Lease 13 Surface Water Hydrology). However, the flood levels mapped in Fig. D4-18 do not agree with elevations shown in the cross sections.
Response	See the response to DFO 12.

Question No.	**4.1**
Shell No.	**DFO 15**
Issue	**Surface Water– Hydrology**
Request	On page F4-9, it states that "There will be no CT perimeter seepage discharges to receiving streams from the Muskeg River Mine Project . . . " This is a contradiction with the simulations and conclusions presented in other sections (e.g., E-3 and Appendix IV).
Response	This inconsistency is acknowledged.

Question No.	**4.1**
Shell No.	**DFO 16**
Issue	**Surface Water– Hydrology**
Request	A contradiction with previous sections also appears in the statement about negligible release of CT pore water into the overburden.
Response	The statement should be revised to "There will be negligible CT perimeter seepage discharges to the Muskeg River from the Muskeg River Mine Project". During the operational phase, no CT water will be released to the river, because the CT surfaces will be much lower than the original ground. During reclamation and after closure, the majority of the CT porewater release will be collected by the surface drainage systems, because the sands overlying the CT are much more pervious than the seepage medium of overburden soils and the hydraulic gradients driving the CT seepage towards the Muskeg River are very low. See also the response to DFO 25.

Question No.	**4.1**
Shell No.	**DFO 17**
Issue	**Surface Water– Hydrology**

Request

Table F4-6, in the Far Future snapshot, there are 53.2 km^2 missing from the original area, what happened to this area?

Response

The small reduction in drainage area of the Muskeg River basin results from the layout of the drainage systems for the Aurora North Mine, which will involve diversion of a small portion of the Muskeg River drainage area directly to the Athabasca River.

Question No.	**4.1**
Shell No.	**DFO 18**
Issue	**Surface Water– Hydrology**

Request

Table F4-7, in the footnote it states that perimeter CT seepage, and CT upward flux, etc. ... will occur throughout the year, however why does the table show zero values only?

Response

If there is perimeter CT seepage, CT upward flux, and sand storage seepage, it will occur year round. However, there are no such seepage discharges to receiving streams during some years. Therefore, the table shows zero values for some of the time snapshots.

Question No.	**4.1**
Shell No.	**DFO 19**
Issue	**Surface Water– Hydrology**

Request

Table F4-8, the 'after 2030' values are presented as negligible, why not put the actual values. Even a relatively small discharge rate (~.03 m^3/s) will amount to a million cubic metres per year.

Response

An increase of 2% in the mean annual flow is not measurable because the flow measurement accuracy is within ±5%. The estimated increase in stream flow sediment concentration is much less than 2%, which is well within the range of natural variability.

In EIA Volume 4, Table F4-8, the values presented as 'negligible' for the period after 2030 can be replaced by 0.09 m^3/s (average increase of mean annual discharge), 2% (percent increase of mean annual discharge), 0.09 mg/L (average increase of stream flow sediment concentration), and 0.9% (percent increase of stream flow sediment concentration).

Question No. 4.1

Shell No. DFO 20

Issue Surface Water– Hydrology

Request

On page F4-13, the treatment of channel erosion of the Muskeg River is simplistic. Erosion along a meandering river can be highly variable. A lot of localized erosion can occur if the vegetated banks are disturbed or the hydrology is altered.

Response

Disturbance to the banks of the Muskeg River by the Muskeg River Mine Project will be limited to the construction of some drainage channels, the bridge and product/diluent pipelines.

It is expected that all sections of the river reach downstream of the project would experience similar rates of erosion. However, constricted reaches and outside river bends might experience slightly higher erosion rates than the other locations. Based on Golder Associates' experience with other similar rivers, if the average erosion rate results in 0.8 mm depth soil erosion, the localized erosion is from two to five times the average rate or 1.6 mm to 4 mm. This would still be classified as negligible.

Question No. 4.1

Shell No. DFO 21

Issue Surface Water– Hydrology

Request

On page F4-15, third paragraph, the numbers for summer and winter flow (0.5% and 3.3%, respectively, and Table F4-14) do not agree with the data presented in Table F4-13. I get 2.1% and 13.2% for summer and winter, respectively. Do water allocations vary throughout the year?

Response

Water allocations vary throughout the year for non-oil sands users (see note (b) of Table F4-12 in EIA Volume 4). The percentages in Table F4-14 are correct.

Question No. 4.1

Shell No. DFO 22

Issue **Surface Water– Hydrology**

Request On page G4-8, again, the claim is made that there will be no CT seepage into the Muskeg River. This contradicts the simulations.

Response See the response to DFO 15.

Question No. 4.1

Shell No. DFO 23

Issue **Surface Water– Hydrology**

Request On page G4-9: A general question about muskeg dewatering. How can muskeg dewatering contribute to low flows on the Muskeg River when the lowest flows occur during the winter when the muskeg is frozen?

Response Muskeg drainage discharge from the Muskeg River Mine Project during winter was assumed to be negligible. The discharge was assumed to occur only in the open-water season (see note (a) of Table G4-10 at the end of this section. However, overburden dewatering from Aurora North and South Mines will contribute to low flows in winter, because the Aurora Mines have more pervious overburden soils than the other mines in the region.

Question No. 4.1

Shell No. DFO 24

Issue **Surface Water– Hydrology**

Request Table G4-19, how where the percentages derived?

Response Percentages were derived based on the water yields from various reclaimed surfaces presented in EIA Volume 3 Part 1, Table E4-18, proportions of various types of reclaimed surfaces for various projects, and natural runoff yields at the project areas.

Question No. 4.2

Shell No. DFO 25

Issue Surface Water– Hydrogeology

Request

Based on the Shell report, in-pit storage of CT (consolidated tailings) deposits will affect surface water. The poor quality CT pore water will first seep into the capping overburden deposits during consolidation of the CT. Once in the overburden, the CT pore water can migrate laterally through the overburden and into the Muskeg River. The estimates show that it would take 104 to 990 years to flush the contaminated pore water completely out of the overburden by precipitation (E3-23). This means that any CT pore water in the overburden will degrade the groundwater quality for many years. Consequently, this contaminated water will seep into the Muskeg River for many years until it is flushed out. The amount of degraded groundwater seeping into the Muskeg River will depend on the proportion of pore water derived from the CT in the overburden. Estimates show that groundwater will seep laterally into the Muskeg River at an ultimate rate of 106.1 m^3 per day (pits 1, 2 and 5, E3-18).

Response

The potential movement of CT seepage in the reclaimed landscape is illustrated in Figures 1 and 2 at the end of this section.

Discharge of mine seepage is very small compared to flows in the Muskeg River. For example, 0.001 m^3/s seepage is only 0.1% of mean winter flow (1.11 m^3/s); < 0.02% of mean annual flow (5.28 m^3/s); and < 2% of the 7Q10 low flow. Therefore, no detectable change is expected in Muskeg River water quality as a result of mine seepage.

The assumptions used in the CT and seepage analysis were conservative because:

- The time required to flush CT porewater from overburden assumed all pore space in overburden filled with CT porewater, up to ground surface.
- The estimated quality of seepage from reclaimed mine pits does not account for mixing recharge water with CT porewater. Note: The total average daily recharge to Pits 1, 2, 3 and 5 is 423.9 m^3/d versus seepage to the Muskeg River of 106.1 m^3/d (0.001 m^3/s). In addition, recharge has the potential to significantly dilute CT porewater in seepage. This is not accounted for in the seepage calculation.

The model does not include natural recharge between the pit and the Muskeg River because:

- natural recharge will reduce the hydraulic gradient between mine pit and river and, therefore, will reduce seepage from mine
- natural recharge will also mix with and dilute mine seepage

Travel time from the mine pit to the Muskeg River is 140 to 990 years, so there will be ample time for dilution from natural recharge in unmined land along this flow path.

Question No. 4.2

Shell No. DFO 26

Issue **Surface Water– Hydrogeology**

Request

Seepage into Isadore's Lake and the Athabasca River (E3-21, 24): The Shell report states that no horizontal seepage would occur from the CT pits into the Athabasca River and Isadore's Lake because of seepage calculations in section 3.6 and that "there is no continuous horizontal flow path." This conclusion is made because the mine is almost entirely bounded by the end pit lake, which would intercept the seepage. However, from the evidence provided, if CT pore water migrates into the overburden and discharges into the end pit lake, it must eventually get into Isadore's Lake and Athabasca River. Figure IV-31, Appendix IV, shows lateral seepage at the base of the end pit lake toward the Athabasca River.

Response

No mine seepage to the west of the mine pits is expected because mine seepage is intercepted by the end-pit lake (the lake will lose water to pits containing CT [Pits 4 and 5]), and will receive seepage only from Pit 6 (sand-capped overburden).

Isadore's Lake water quality is not expected to be affected because of the interception of CT by the end-pit lake. About 103 m^3/d of non-contaminated water from the end-pit lake surface might be transmitted via the overburden to Isadore's Lake.

Permeable Quaternary deposits do not extend to the Athabasca River, but are truncated by the Athabasca River valley wall. Therefore, surficial seepage is not expected to reach the Athabasca River.

In addition, to the west of Pit 5, the hydraulic head in unmined land is expected to be much higher than the head within Pit 5. In particular, to the west of Pit 5 (elevation 282 to 290 m), the West Dump has an elevation of 340 masl, the native unmined land has an elevation >300 m, and the Sand Storage area has an elevation of 325 m. This is expected to induce groundwater flow to move from unmined land toward Pit 5 (i.e., west to east, toward the Muskeg River). Shallow groundwater flow to the west of Pit 5 should be intercepted by the drainage channel from the Sand Storage Area and would not discharge to the Muskeg River.

CT that might find its way into the basal aquifer would have a 15-year travel time to the Athabasca River. However, the rate and volume of seepage from this source into the Athabasca River is extremely small compared to the flow of the Athabasca River. Therefore, no effects on the river are expected from this source. There is no evidence that the basal aquifer is continuous under Isadore's Lake.

Therefore, neither the quality of Athabasca River water nor Isadore's Lake water is expected to be affected by CT seepage.

Question No.	**4.2**
Shell No.	**DFO 27**
Issue	**Surface Water– Hydrogeology**

Request

Rates of seepage discharge, Table E3-3: Based on estimations of hydraulic conductivity (K), the discharge rates seem reasonable (2-D approximations). However, it should be noted that K can have a range of values. For example, the Basal aquifer has values ranging two orders of magnitude ($3 X 10^{-3}$ to $5 X 10^{-5}$ m/s, Komex 1997). Several 3-D groundwater modeling programs are available, making more accurate, 3-D simulations possible.

Response

Two-dimensional cross-sections are located at the point where the pit is closest to the river, and these represent a worst case setting. The seepage value is applied to the entire length of the pit perimeter. Therefore, it is very conservative.

A substantial amount of hydraulic conductivity (K) data is available only for the basal aquifer:

- Little K data is available for oil sands, lean oil sands, unmined overburden, CT, cast overburden and tailings sand.
- The model is not very sensitive to the hydraulic conductivity of the basal aquifer, since this unit is always much more permeable than overlying materials, and is handled with constant heads at both ends of the model cross-section.
- hydraulic conductivity values used in simulation represent best professional judgment (i.e., best estimate), with limited hard hydraulic conductivity data.

Question No.	**4.2**
Shell No.	**DFO 28**
Issue	**Surface Water– Hydrogeology**

Request

Figures E4-5 through to E4-8 show surface water drainage and diversions systems which appear to be in part compromised by the 1:10 and 1:100 year floods. This includes the polishing pond located on the west side of Jackpine Creek, one of the polishing ponds near the processing facility as well as portions of the south storage area; only the storage area and road embankments are identified within the 1:100 year floodplain (E4-62). It would seem reasonable to expect the highest inputs of sediment to coincide with higher flow events. The apparent location of some of the polishing ponds within the floodplain may compromise their function of sediment retention/reduction. The exposed south storage area and portions of the mine pit are also likely to contribute sediment. Given the longevity of the proposed development and its potential to impact the environment one would also have to question whether the 1:10 or 1:100 year flood standards offer the most appropriate level of protection.

Response

Some of the polishing ponds are located within the 100-year flood risk limits. Embankments will be provided around the polishing ponds to protect them against any inundation. Shell will conduct a detailed design of all water management facilities before construction. During this final design stage, locations of the polishing ponds will be optimized to minimize the risk of 100-year flood inundation and costs for constructing the embankments.

Mitigation measures will be provided to minimize the erosion of the embankments and storage facilities located within the 100-year flood risk limits. These mitigation measures are discussed in EIA Volume 3, Part 1, Pages E4-62 and E4-63.

We believe that the 100-year design standard is appropriate for the Muskeg River Mine Project. AEP and the Canada Flood Damage Reduction Program require that all municipalities in Alberta be protected for 100-year flood events. The potential risk of flooding damage at the Muskeg River Mine Project area is not expected to be higher than those at large municipalities, such as Calgary and Edmonton, where there are residential and commercial properties and residents living within the 100-year flood risk limits.

Question No. **4.2**

Shell No. **DFO 29**

Issue **Surface Water – Quality**

Request

Given some concern over the assessment criteria used in Table E1-9, the key questions WQ1 and WQ2 as stated in E5.3 might be better presented as "How will operational and reclamation releases from the project affect the water quality of the Athabasca and Muskeg Rivers and Isadore's Lake?" and "Will operational and reclamation water releases from the project contribute toxicity to the waters of the Athabasca and Muskeg Rivers and Isadore's Lake?"

Response

The modeling predictions and conclusions reached would not be altered by the suggested key question rearrangement.

Question No. **4.2**

Shell No. **DFO 30**

Issue **Surface Water– Hydrogeology**

Request

The stream sediment monitoring program identified with the RAMP programs (E4-68) and future studies as laid out in E4.7.3 should continue to be pursued as there are likely to be residual concerns regarding the performance of the engineered solutions proposed for the reclaimed landscape.

Response Section 7.2 (Monitoring and Research) in the Project Update summarizes the long-term monitoring program that Shell proposes for the Muskeg and Athabasca rivers. Shell will install water quality stations for TSS and other parameters to monitor the effects of the Muskeg River Mine Project, including end-pit lake releases. These stations are being recommended in addition to those already in place for RAMP. See also the response to AEP 35 on Shell's Monitoring Committee.

In addition to these monitoring programs, as part of the future study identified in EIA Volume 3, Part 1, Section E4.7.3, the sediment yields from reclaimed surfaces of the Muskeg River Mine Project will be monitored and studied to provide a basis for identifying the best landscape option.

Question No. 4.3

Shell No. DFO 31

Issue **Thermal Impacts**

Request The potential for changes in the thermal regime of the Muskeg River and associated impacts on the aquatic environment needs to be explored in more depth. The analysis provided in the EIA examines the potential impact on fish by examining HSI curves for several fish species (Figures E6.5 and E6.6). Potential impacts on the benthic invertebrate community have not been examined yet this is likely to be where impacts first occur. Reduced water temperature and the disturbance of diurnal and seasonal patterns can significantly impact the aquatic invertebrate community (Wiederholm, 1984). The potential impacts of changes in the thermal regime on the various life stages of fish and benthic invertebrates should be explored before describing the effect as "negligible" (Table E5-14).

Response The effects of temperature on benthic invertebrates are discussed in Section 7.1 (End-Pit Lake Discharge) in the Project Update.

Question No. 4.3

Shell No. DFO 32

Issue **Thermal Impacts**

Request The capacity for reduced diurnal fluctuation also needs to be explored.

Response Use of monthly median temperatures:

Comment acknowledged. Monthly median temperatures for the Muskeg River were used in the analysis, because insufficient data on daily temperatures were available. However, more detailed baseline data on temperatures are being collected for the Muskeg River as part of RAMP and will allow a more detailed assessment to be conducted.

Question No. 4.3

Shell No. DFO 33

Issue **Thermal Impacts**

Request

Comparisons made to monthly median temperatures may mask the natural variation between daily temperatures as well as the diurnal variation. The "undetermined" status regarding the issue of diurnal fluctuation appears to be inexplicably dismissed in latter sections of the report (E6-34, E16.6.7). Under the cumulative effects assessment, in spite of a predicted decrease in open-water temperatures of 2.6° C around 2007, the impact assessment (Table F5-9) still identifies an effect of negligible magnitude and negligible concern. Similarly the previously undetermined nature of the diurnal fluctuation is now rated as low.

Response

Impact classification:

Comment acknowledged. Diurnal fluctuation should be rated "Undetermined" in all sections. The rating of "Negligible" referred to in the comments is consistent with the impact criteria definitions (see EIA Volume 3, Part 1, Table E1-9), as the predicted temperature change (2.6°C) is below the applicable guideline of 3°C.

Question No. 4.3

Shell No. DFO 34

Issue **Thermal Impacts**

Request

Under the cumulative scenario, temperatures in the Muskeg River are expected to decrease by 2.6° C during open water and increase by 1° C during winter around 2007. Around 2030, the predicted change in thermal regime will be 1.8° C. All of these values are expressed on the basis of monthly median water temperatures (Figure F5-1). It is not clear what flow conditions are represented here and what the effect would be under low flow conditions, particularly as the 7Q10 flows are expected to increase by 632% from 0.281 m^3/s to 2.058 m^3/s in 2007 and to 2.29 m^3/s in 2030 (Table F6-4).

Under these conditions the majority of flow would originate from dewatering and end pit lake releases. The assessment carried forward to the RDR provides for the decrease of 2.9° C which again is below the "acceptable" level and therefore impacts are categorized as negligible. Overall, for the various scenarios presented the predictions apparently fall within the "acceptable guidelines" (3° C) and hence the predicted changes in water temperature are classified as negligible.

Reference to these guidelines is made throughout the report - but these guidelines are never identified. Further information on the acceptability of these guidelines and their application to the conditions described should be provided.

Response

The guideline used for the assessment is the *Alberta Ambient Surface Water Quality Interim Guideline* (AEP 1993). According to AEP, its guidelines have been developed to provide for "long-term protection of important sensitive fish, plant and animal species or other water uses".

Shell is committed to monitoring temperature in the Muskeg River under baseline conditions and during mine development (see Section 7.2, Monitoring and Research, in the Project Update).

Question No. **4.4**

Shell No. **DFO 35**

Issue **Regional Aquatics Monitoring Program – RAMP**

Request

Numerous references are made to the Regional Aquatics Monitoring Program, however, there is no information on the objectives of the program, the framework for its implementation or the commitment to its continuation after project approvals are in place. If Shell Canada and the other oilsands operators have a commitment to the RAMP then details of that commitment should be provided. Specific comments regarding the RAMP Report will be provided by DFO-HMD under separate cover.

Response

As identified in Section 7.2 (Monitoring and Research) in the Project Update, Shell will work with other industries to ensure that clear objectives and a long-term mandate are set for the regional aquatic monitoring programs. Shell is committed to conducting life-of-project monitoring programs that have been designed to protect aquatic resources in the Muskeg and Athabasca rivers. See also the response to AEP 35 on Shell's Monitoring Committee.

Question No. **5.1**

Shell No. **DFO 36**

Issue **Groundwater – Diversion and Dewatering**

Request

Overburden dewatering and mine pit development is predicted to cause some drainage of surficial aquifers in the range of 1 to 2 km from the mine (E3-8, E4-37). This will result in the reduction of surface runoff of about 40-61 mm/year over the affected area. It is further stated that the drawdown, which will peak around 2022, will translate into about a 0.1% reduction in mean annual flow of the Muskeg River and similarly a 11% reduction for the Mills Creek basin. The significance of the flow reductions for Isadore's Lake are readily apparent from Table E4-15, particularly for low flow conditions.

Response In 2022, the mean annual inflow to Isadore's Lake will be reduced by 23%. The water balance analysis of Isadore's Lake presented in EIA Volume 3, Part 1, Table E4-17, shows that the resulting reduction in the lake water level for the 10% exceedance condition (this condition will be exceeded 10% of the time) will be 6 mm, for the median condition it will be 15 mm, and for the 90% exceedance condition (which will be exceeded 90% of the time) it will be 30 mm. These changes are considered to be low to negligible.

Question No. **5.2**

Shell No. **DFO 37**

Issue **Basal Aquifer Drawdown**

Request Depressurization of the Basal Aquifer from the mine development area is predicted to have a measurable drawdown effect within a range of 30 to 40 km. A drawdown effect of greater than 20 m is predicted to occur within approximately 11 km (E3-11) from the minesite. The contribution of the Muskeg River Mine to the drawdown of the Basal Aquifer is expected to result in increased seepage losses of 14 mm/year above the naturally occurring seepage of 15 mm/year from Kearl lake. The cumulative loss for all developments in the Muskeg River Basin is estimated at 63 mm/year or about 14% of annual precipitation. Although the analysis has extended to examining the effect on lake levels, it is not clear if reduced discharges from Kearl Lake and surrounding wetlands have been factored into the hydrologic analysis of the Muskeg River flows. It is stated that the above are worst case estimates based on the assumed hydraulic conductivity of $2x10^{-9}$ m/s. A similar analysis is provided for Isadore's Lake and McClelland Lake.

Response Reduced discharges from Kearl Lake and surrounding wetlands have been considered in the hydrologic analysis of the Muskeg River flows.

Question No. **5.2**

Shell No. **DFO 38**

Issue **Basal Aquifer Drawdown**

Request Under E4.3.2 the increased losses from Kearl Lake to the Basal Aquifer are identified as 81,600 m^3/year, which compared to the natural losses of 72,000 m^3/year and annual inflow of 10. 4 million m^3/year represents 0.8% of the total lake inflow. However, it is not clear that the computation that arrived at the value of 0.8% in fact represents the increased losses or the total losses from Kearl Lake. Based on the data available to the reviewer it would appear that the increase of 9600 m^3/year would only represent 0.09% of the total inflow. It is also not clear why a value of 17 mm/year was used compared to the previously stated value of 14 mm/year. Further clarification is required here.

Response We acknowledge the discrepancy of the increased deep percolation losses between 17 mm/a stated in the surface water hydrology section and 14 mm/a stated in the hydrogeology section. The value of 14 mm/a is the updated estimate. Basal aquifer depressurization at the Muskeg River Mine Project will cause negligible impacts on the Kearl Lake water balance.

The second paragraph in EIA Volume 3, Part 1, Section E4.3.2 on page E4-57 should be revised as follows:

"The deep percolation loss from the lake to the basal aquifer was estimated to be 15 mm per year (72,000 m^3 per year) during natural conditions as discussed in Section E3. Basal aquifer depressurization during operation at the Muskeg River Mine Project area will increase deep percolation losses by up to 14 mm per year equivalent to 67,200 m^3 per year. This compares with the mean annual inflow of 10.4 million m^3 to Kearl Lake. The increased losses to the basal aquifer represent only 0.6% of the total lake inflow. This is very small and can be considered to be negligible."

The relevant data on deep percolation losses to the basal aquifer are summarized as follows:

- total loss for natural conditions: 72,000 m^3/a
- total loss for future conditions (Shell only): 139,200 m^3/a
- increased loss (Shell only): 67,200 m^3/a

Question No. 5.2

Shell No. DFO 39

Issue **Basal Aquifer Drawdown**

Request Potential drawdown effects of the Basal Aquifer (E3-12): The calculations show that pumping the Basal Aquifer will increase the downward seepage from Kearl Lake from 15 mm/a to 29 mm/a. This is a significant 93.3 % increase in seepage loss from the lake. Lakes with stable water levels represent an equilibrium of climatic and geologic conditions (precipitation and recharge = discharge and evaporation). Therefore, comparing the downward seepage rate with mean annual precipitation (E3-12) for assessing impacts is irrelevant.

Response The calculations employed to predict basal aquifer depressurization effects on the Kearl Lake water balance were based on worst-case, conservative assumptions and the effects on Kearl Lake water balance are not expected to be measurable. The following assumptions were used:

- Kearl Lake loses a small portion of its water to the basal aquifer through vertical seepage or deep percolation.

- The basal aquifer is separated from the lake bottom by a substantial thickness (about 80 m) of sediments (mainly oil sands) with very low permeability.

Conservative Estimates of Seepage Losses from Kearl Lake to the Basal Aquifer:

- Baseline = 15 mm/a

- Shell alone = 29 mm/a (increase of 14 mm/a)
- CEA/RDR = 63 mm/a (increase of 48 mm/a)

Effects on Kearl Lake Water Balance:

The lake water balance is presented in Figure 3 at the end of this section. The effects on Kearl Lake water levels are presented in Figure 4 at the end of this section.

Shell Alone:

Incremental Seepage Loss of 14 mm/a Represents:

- 3% of mean annual precipitation
- 2% of mean annual lake evaporation
- 0.7% of mean annual basin inflow

Effects on Lake Water Balance:

- 1 mm drawdown in mean lake level
- 0.7% reduction in mean lake outflow

CEA/RDR:

Increased Seepage Loss of 48 mm/a Represents:

- 11% of mean annual precipitation
- 8% of mean annual lake evaporation
- 2% of mean annual basin inflow

Effects on Lake Water Balance:

- 2 mm drawdown in mean lake level
- 2.5% reduction in mean lake outflow

Mitigation:

If unacceptable declines in lake levels and outflows are forecast based on the monitoring program, this impact could be mitigated by re-injecting basal aquifer water into wells strategically located around the perimeter of the lake, in order to maintain the hydraulic head in the basal aquifer closer to natural conditions, and reduce downward losses from the lake or wetlands. Water to supply this activity could be supplied by a number of operators, including Aurora South, Mobil or Shell East.

Question No. 5.2

Shell No. DFO 40

Issue **Basal Aquifer Drawdown**

Request

The calculations are based on the fact that Kearl Lake is separated by 80 m of low-permeability oil sands, Cretaceous and Quaternary sediments (E3-11). Where are the figures or cross sections that confirm this value?

Response

The discussion on the presence of the 80 m low-permeability oil sands is in Appendix D, page D-12 of the EIA for the Syncrude Aurora Mine (BOVAR, 1996). Much of this information is based on work by Ozoray et al. (1980) of the Alberta Research Council.

Question No. 5.2

Shell No. DFO 41

Issue **Basal Aquifer Drawdown**

Request

Figure 2-5 (Geology of Lease 13) shows an extensive Pleistocene channel, and it appears that Kearl Lake, lying just outside the figure, must coincide with that channel. How does the presence of the Pleistocene channel affect seepage from the lake?

Response

The distribution of the Pleistocene Channel as shown in the Aurora EIA suggests that the channel might extend beneath Kearl Lake, but the data are limited in the immediate vicinity of Kearl Lake. The Pleistocene Channel is located entirely to the east of the Muskeg River and the Muskeg River Mine is not expected to have any direct effect on groundwater in the Pleistocene Channel.

Groundwater conditions in the Pleistocene Channel will be dominated by groundwater recharge events reflecting seasonal or annual conditions, with discharge to the lake determined by the hydraulic gradient between the lake and the aquifer. If Kearl Lake and the Pleistocene Channel are hydraulically connected, the groundwater discharge from the aquifer could help to buffer seepage losses from the lake.

Question No.	**5.2**
Shell No.	**DFO 42**
Issue	**Basal Aquifer Drawdown**

Request

A potentially significant factor to the wetlands is the presence of impermeable permafrost. This area is within the zone of discontinuous permafrost (GSC Map 1246A) and permafrost has been reported south of the project area. The Wetlands Baseline (Golder 1997) and section D-8 do not discuss permafrost.

Response

No cryosolic soils (permafrost) were observed in the LSA (see EIA Volume 3, Part 1, Section E8-2). In addition, the Alberta Wetland Classification (AWI) was designed to identify permafrost features on aerial photographs (see EIA Volume 4, Figure D10-2). However, no permafrost features were observed in the field or identified on aerial photographs. The wetlands occurring in the LSA are described in EIA Volume 4, Section D10.

In addition, the 1997 and 1998 drilling programs did not encounter any permafrost.

Question No.	**5.2**
Shell No.	**DFO 43**
Issue	**Basal Aquifer Drawdown**

Request

Another important consideration is the additional drawdown imposed by the Aurora Mine project (Section E3). A further depressurization of the Basal Aquifer will increase downward seepage from Kearl Lake by 320%. Under these conditions, Kearl Lake will dry up given enough time.

Response

See the response to DFO 39.

Question No.	**5.2**
Shell No.	**DFO 44**
Issue	**Basal Aquifer Drawdown**

Request

Kearl Lake, Muskeg River and Jackpine Creek areas have all been designated as environmentally significant areas (D14-13). Kearl Lake is hydrologically important, the Muskeg

River is important to fish and East Jackpine Creek is both hydrologically and biologically important to fish.

How has this consideration been accounted for in the project, cumulative and regional assessments?

Response

Muskeg River, Jackpine Creek and Kearl Lake are regionally significant waterbodies. These waterbodies are not ranked as significant from a provincial or national perspective (see EIA Volume 2, Table D14-3).

Protection of these waterbodies has been considered in the development of the Muskeg River Mine Project. The approach taken to maintain the long-term sustainability of the Muskeg River and Jackpine Creek has been to avoid direct physical alteration of the rivers and to maintain a suitable flow regime and the quality of the water in the rivers.

Impacts on the Muskeg River were assessed as part of the Cumulative Effects Assessment (CEA) (see EIA Volume 4, Section F6) and the Regional Development Review (RDR) (see EIA Volume 4, Section G6).

No effects on Jackpine Creek are expected as a result of additional developments in the watershed. Therefore, it was not explicitly discussed in the CEA or RDR.

Kearl Lake is not on Shell's lease and would not be directly affected by the Muskeg River Mine Project. The potential for hydrological effects on Kearl Lake from the project was addressed in EIA Volume 3, Part 1, Section E4.3.1. For the effects of basal aquifer depressurization on Kearl Lake from the Muskeg River Mine Project and CEA/RDR, see the response to DFO 39.

Question No. **5.2**

Shell No. **DFO 45**

Issue **Basal Aquifer Drawdown**

Request

In a supplemental response, dated March 6, 1998, Shell states that the assessment of drawdown effects would need to be verified by monitoring groundwater levels between Kearl Lake and the minesite and lake levels. It is also suggested that unacceptable declines in lake levels could be mitigated by re-injection of water into strategically located wells.

Further details of the monitoring program and contingency measures should be provided.

Response

Shell's groundwater and surface water monitoring program will allow early detection of any changes in hydraulic conditions that might adversely affect lake or wetlands levels. This program will consist of:

- groundwater monitoring adjacent to Kearl Lake, between the lake and the mine pit (see Figure 5 at the end of this section)
- a nest of piezometers completed at various depths between the basal aquifer and the

lake bottom (see Figure 6 at the end of this section)

- hydraulic conductivity of geologic materials in each screened interval being verified by single-well response testing of each piezometer
- periodic monitoring of groundwater levels to assess any changes in hydraulic gradient over time, in conjunction with monitoring the lake level
- lake water level and outflow monitoring

See the response to AEP 35 on Shell's Monitoring Committee. See also the response to DFO 39.

Question No. **5.5**

Shell No. **DFO 46**

Issue **Aquifer Exchange**

Request

Under Section D-3, the five points presented in the Shell report arguing against a connection between the Methy Formation and the Basal Aquifer are valid although the unavailability of raw data from the referenced previous works make it more difficult to evaluate the actual conclusions.

Further clarification on the feasibility of stemming any such connection should be provided along with any contingency plans should contamination by the Methy Formation become unavoidable.

Response

Grouting to control groundwater inflows is a commonly used approach in underground mines, tunnels, and hydroelectric projects. Many of these developments are in karst terrain, where grouting is effectively used.

Grouting has been used in situations technically more difficult than at the Muskeg River Mine.

Grouting for groundwater control along faults is also considered technically feasible.

Therefore, although evidence suggests that the basal and Methy aquifers are not interconnected, even if they were interconnected, the flow between the two aquifers would be minimal and grouting of these potential localized zones of high hydraulic conductivity (K) would be technically feasible.

Question No. 5.5

Shell No. DFO 47

Issue **Aquifer Exchange**

Request

Some potential for karst solution in the Methy Formation exists, which could provide effective conduits between the Methy and Basal Aquifers. Reefal zones are also potential areas of very high hydraulic conductivity. It is possible that these features remain undiscovered in the region because the drawdown effect on the Basal Aquifer will extend for many kilometres.

Response

Information on hydraulic heads and water quality in the aquifer indicates they are not connected. For example:

- Evidence against hydraulic connection between the Methy and the basal aquifer is based on water quality and hydraulic pressure data obtained in hydrogeologic studies for the Alsands project. Specifically:
  - Data are presented in Tables and Figures in the Hydrogeology Baseline Study - Oil Sands Lease 13 (Komex International Ltd. Prepared for Shell Canada Limited. November 1997.
  - Data are being augmented by a hydrogeological exploration program started in Winter, 1998.
- Neither Suncor nor Syncrude mines, operating since 1964 and 1976 (respectively) have encountered inflows from the Methy aquifer into their mine.
- The Methy Formation is overlain by over 100 m of mostly low-permeability (K) sediments. This aquitard should prevent rapid groundwater migration between the Methy and the basal aquifer.
- There might be local zones of high permeability (reefal build-ups) in the Methy, but storage in these zones is expected to be limited.
- Between the high permeability reefs are low permeability limestone and dolostone within the mine area.

See the response to DFO 46 (mitigation) and DFO 45 (monitoring).

Question No.	**6.0**
Shell No.	**DFO 48**
Issue	**End-Pit Lakes**

Request

With regard to closure: - Table E4-19 identifies the effect on flows of the receiving stream after mine closure. The data provided cover both mean and extreme flow conditions. The problem arises in that these conditions may be difficult to correlate with instream flow requirements for the life processes of fish. As an example, it is not clear that any of the flow conditions provided for the Muskeg River would adequately represent the conditions for the period during which fish egg incubation would occur. The increase of 19% for mean open-water flow for the Muskeg River includes the spring flood, which would reduce the apparent differential, which might be evident under lower flow conditions. Similarly, the impact on extreme (7Q10) flow conditions does not provide any insight into the normal summer flow conditions, which may represents the condition when fish generally inhabit the river.

Suitable data for comparison to periods of biological significance should be provided.

Response

See Section 7.1 (End-Pit Lake Discharge) in the Project Update.

Question No.	**6.0**
Shell No.	**DFO 49**
Issue	**End-Pit Lakes**

Request

It is stated that the low retention times for the wetlands located on CT deposits may affect the capability to treat CT release water. The required retention time, which is stated to be in the order of one month, can be compromised by the 2 year and 100 year floods which can reduce retention times to 7 and 2 days, respectively (E16-30). It is also stated that this time frame would likely be too short to allow adequate treatment for undiluted CT release water. High flow conditions would tend to flush chemicals from CT deposits or overlying materials which may accumulate CT related compounds such as salts, metals and naphthenic acids and ammonia. These could severely limit the productivity and capability of the aquatic ecosystem within the wetlands and drainage channels. This would result in result in CT waters being released into the end pit lake over a prolonged period, potentially affecting the productivity of the end pit lake and potentially the Muskeg River. The release of CT waters is a significant issue as it can constitute as much as 24% of the total surface flows following closure. This is expected to reduce to near 0% over more than 100 years (E16-31).

Response

Because CT deposits will be below the surrounding ground level and will release water gradually (over several years), the amount of CT water available to be flushed out of CT deposits during a single storm event will be relatively small. High flows during floods will also provide for considerable dilution of any CT waters flushed out, thereby reducing CT water concentrations considerably. Most CT waters released by these events will be retained in the end-pit lake and will not reach the Muskeg River until their quality is deemed acceptable for release.

It is expected that CT waters will be released to the end-pit lake over a long period (several decades), but high flows of CT water will only occur during the initial dewatering of CT (i.e., in the first and potentially second decade after filling the end-pit lake). Shell recognizes that the release of CT water is an important issue and is intending to use the most up-to-date mitigation techniques to enhance improvement of water quality in the end-pit lake and prevent CT water release from the end-pit lake before its quality is acceptable. Shell will also monitor the end-pit lake to follow the evolution of its water quality. See also the response to AEP 35 on Shell's Monitoring Committee.

Question No. **6.0**

Shell No. **DFO 50**

Issue **End-Pit Lakes**

Request Table E4-22 classifies the degree of concern regarding residual impacts during the end pit lake management period as low to high in magnitude and as moderate in degree of concern.

This analysis should be carried forward to the CEA.

Response See the response to DFO 51.

Question No. **6.0**

Shell No. **DFO 51**

Issue **End-Pit Lakes**

Request The reported release discharge of 1.4 m^3/s from Shell's end pit lake and the combined effect with Syncrude's releases needs to be further explored.

Response The effects of the end-pit lake discharges to the Muskeg River during the management period (2027 to 2031) were considered in the cumulative effects assessment for both the CEA (see EIA Volume 4, Section F4.4.1) and RDR (see EIA Volume 4, Section G4.3.1) scenarios. End-pit lake flows from other developments were included in these assessments. The maximum Muskeg River Mine Project end-pit lake flows do not coincide with the maximum flows of end-pit lakes from other developments.

Question No. 6.0

Shell No. DFO 52

Issue **End-Pit Lakes**

Request

The EIA states that a productive end pit lake will be a part of the closure landscape (E4-46).

There appears to be no convincing evidence to support this assertion.

Response

The suitability of the end-pit lake to support a productive ecosystem is discussed under Key Question WQ-6 (see EIA Volume 3, Part 1, Section E5.10). See also the response to AEP 105 to 114.

Question No. 7.0

Shell No. DFO 53

Issue **Contaminants and Toxicity**

Request

One of the great difficulties in trying to understand the effects of oil sand development on the lower reach of the Athabasca River is separating natural from anthropogenic effects. For example, PAHs are found in the oil sand itself and also in the river. How much is caused by the natural erosion of oil sand and how much by industrial activities within the basin and how much is caused by inputs from outside the basin? We need technologies to separate these and somehow partition existing loadings into these three sources (and any others if they exist). Perhaps the most promising of these is the use of more detailed PAH chemistry but that has not been done in this EIA.

Response

Comment acknowledged. At the current level of knowledge about PAHs in the Athabasca River, it is not possible to separate the contributions from the sources identified. However, it is known that sediments of other northern rivers (e.g., Peace and Wapiti rivers) contain more PAHs than the Athabasca River within the oil sands reach. This suggests that contributions by oil sands operations are small compared to natural sources, as was also speculated by Crosley (1996). Within the oil sands reach of the Athabasca River, the most obvious sources of PAHs are numerous natural outcrops of bitumen along the river and tributary inputs (e.g., the natural oil slick on the Steepbank River or eroded oil sands carried in as suspended sediments). These observations are consistent with results of water quality modeling conducted for the Muskeg River Mine Project EIA, which showed that, even using conservative assumptions (e.g., maximum PAH concentrations in oil sands-related release waters), the contributions of PAHs to surface waters would be very small.

The PAH monitoring program initiated as part of RAMP and additional monitoring proposed by Shell is expected to provide the information necessary to first characterize existing PAH levels in environmental media (sediment water column, suspended sediment), and subsequently, to develop techniques to separate loadings of these substances from various sources. In addition, Shell is recommending a review of the existing literature on sediment coring in the region to assess PAH levels during the pre-development oil sands period compared to the post-development period. See Section 7.2 (Monitoring and Research) in the Project Update for more details on the PAH monitoring and research programs.

Complete PAH data sets are provided in Attachment 1.

Question No. 7.0

Shell No. DFO 54

Issue Contaminants and Toxicity

Request

Sec. D5.2.1 - With regard to oil sands projects in general, perhaps the principal chemical issues are hydrocarbons. This section contains surprisingly few hydrocarbon data and those listed are of poor quality. Athabasca River water was found to have "Concentrations of naturally occurring hydrocarbons have been consistently low in the Athabasca River throughout the period of record". Does this mean that the hydrocarbons are present in the river water exclusively as a result of natural processes? If hydrocarbons are found in the water at all, one should expect to see them mostly adsorbed to suspended solids. There is also some question whether the water data were obtained on filtered or unfiltered samples.

Response

The statement in question in the third sentence of the comments should read "Concentrations of hydrocarbons have been consistently low in the Athabasca River throughout the period of record". Therefore, concentrations would include both natural and artificial sources of hydrocarbons. Hydrocarbons were measured in unfiltered river water samples. Therefore, detectable concentrations were likely associated with suspended sediments.

Question No. 7.0

Shell No. DFO 55

Issue Contaminants and Toxicity

Request

With regard to sources, one would expect a mixture with some PAH derived from the erosion/leaching of the bitumen deposits, some from human activities within the drainage and some from atmospheric fallout originating outside the drainage. This begs the question of how the "naturalness" of the hydrocarbons was established?

How were sources resulting from human activities ruled out?

Response

As noted in the response to DFO 53, the PAHs measured in surface waters and sediments in the oil sands region cannot be attributed to individual sources at this time. However, because of the prevalence of bitumen outcrops in the region, natural inputs likely contribute the majority of PAHs in surface waters and sediments.

Question No.	**7.0**
Shell No.	**DFO 56**
Issue	**Contaminants and Toxicity**
Request	Sec. D5.2.2 - Pretty much the same questions apply to this section as to Sec. D5.2.1. Since the individual PAHs in Table D5-4 are mostly below detection limits, and the total PAHs are in the range of 130 to 1203 ng/g, the figures as listed do not add up. There must be quite a number of other PAHs not tabulated here but included in the total.
Response	Only representative PAHs were shown in the EIA to simplify presentation. The compounds shown were chosen on the basis of the availability of a water or sediment quality guideline. Complete PAH data sets are provided in Attachment 1.

Question No.	**7.0**
Shell No.	**DFO 57**
Issue	**Contaminants and Toxicity**
Request	Furthermore the "Total PAHs" data do not agree with the "Recoverable Hydrocarbons" which implies, not surprisingly, that materials other than PAHs are contributing to the latter figure. This table needs to be expanded to include the concentrations of all the PAHs and other hydrocarbons measured.
Response	As noted, there is no reason why total PAHs should agree with recoverable hydrocarbons, as only a relatively small proportion of the hydrocarbons measured is contributed by PAHs. The same analyte lists were used for all PAH analyses shown in EIA Volume 2, Tables D5-4 , D5-5 and D5-9. Therefore, the results are directly comparable.

Question No.	**7.0**
Shell No.	**DFO 58**
Issue	**Contaminants and Toxicity**
Request	As tabulated, we cannot make valid comparisons among total PAH numbers tabulated here with those from other studies because we do not know which PAHs contributed to the total.

However, the figures for "total PAHs" are, with the exception of the site 1 km above Tar Island Dyke in 1994, in the same range as those in sediments from other "uncontaminated" locations, assuming that the totals represent roughly the same components. For example, Lake 375 at the Experimental Lakes Area in Ontario had "total PAHs" in the range of about 530 to 850 ng/g in the top few slices of a core. In this lake, however, the organic carbon content was much higher, about 130 mg/g or 13 % as compared with only 0.49 – 2.32 %. It is valid to compare the individual PAHs, namely phenanthrene, benzo(a)anthracene/chrysene, fluoranthene and pyrene. The table below lists the concentrations of individual PAHs from Table D5-4 and from Lake 375 at ELA (unpublished data) and the Athabasca River PAHs are generally similar to or lower than the lake sediments, with the exception of one site. Clearly the Athabasca River site on the west bank 1 km above Tar Island in 1994 was quite highly contaminated but that situation did not persist into 1995 or 1997.

What is the explanation for the 1994 result?

Response

The most likely source of the PAHs at the Athabasca River site on the west bank 1 km above Tar Island in 1994 is material eroded from bitumen outcrops, which are common in this reach of the river. There are no oil sands-related discharges upstream from this site, other than mine drainage water inputs from Syncrude through Poplar Creek, which have not been identified as a significant source of PAHs. The difference in results between 1994 and 1995 most likely reflects redistribution of bottom sediments during high flows, a phenomenon which is common in the lower Athabasca River.

Question No. **7.0**

Shell No. **DFO 59**

Issue **Contaminants and Toxicity**

Request

Carey et al. (1990) reported phenanthrene at 37 ng/g in the suspended solids of the Mackenzie River near Fort Simpson and fluoranthene at 10 to 110 ng/g at two other sites further downstream. The "Total PAHs" in the Mackenzie data ranged from 52 to 418 ng/g. Working with river sediments is always difficult because the environment can switch from erosional to depositional within short distances and sedimentation characteristics can change over seasons with variable flow. In order to make much sense out of the data in Table D5-4, we need to know something about the nature of the sedimentation at the sampling sites.

Were they in fact sites where sediments accumulate?

Response

The sediment samples analyzed were fine sediments collected from areas that were depositional at the time of sampling. Because of the high sediment load and shifting sand bottom of the Athabasca River, sediment samples most likely represent recently deposited sediments. The data presented in the EIA was summarized from previous sediment surveys, or current studies independent of the Muskeg River Mine Project EIA. Therefore, it was not possible to control the locations sampled.

Question No. 7.0

Shell No. DFO 60

Issue **Contaminants and Toxicity**

Request

Table D5-5 - It is notable that the Microtox IC-50 was always over 100%, meaning that the production of light by the bacteria was not inhibited to the extent of 50% even by 100% porewater.

Was there any effect at all?

That is, was the production of light reduced below the control even if it was less than 50%?

If so, then the actual dosage/response lines should be given, not just the IC-50 statistic.

Response

Microtox IC_{20} values were also less than 100% in the samples shown in EIA Volume 2, Table D5-5, indicating the lack of toxicity to bacteria and, hence, no effect.

Microtox data are not available for commercial naphthenic acid mixtures for comparison with the porewater samples in which naphthenic acid concentrations were elevated (Table D5-5). Based on recent test results for CT water produced by Suncor, concentrations of naphthenic acids below 20 mg/L are unlikely to be toxic to bacteria. For example, CT water with a naphthenic acid concentration of 78 mg/L was tested during the most recent Suncor studies, and results for all toxicity tests matched well with those of previous tests of CT waters. The 22.7% dilution of CT water (corresponding to a naphthenic acid concentration of about 18%) caused 25% light reduction in the Microtox test, which represents marginal toxicity. However, as CT water might contain other toxicants that likely contributed to the observed toxicity, the effect of naphthenic acids alone on light inhibition would likely be less than the 25% measured.

Question No. 7.0

Shell No. DFO 61

Issue **Contaminants and Toxicity**

Request

Was there a positive control so that we can tell whether the microorganisms were in fact responsive?

Response

Positive controls were used for the Microtox tests, using a reference toxicant, as required by the Environment Canada protocol followed to conduct the tests.

Question No. 7.0

Shell No. DFO 62

Issue **Contaminants and Toxicity**

Request This table apparently includes data from 1994 and 1995 but it is not readily apparent which figures came from which year; that should be made clear.

Response The date 1994 is in error. All samples shown in Table D5-5 were collected in 1995, during the Suncor-Syncrude baseline studies (Golder Associates 1996).

Question No. 7.0

Shell No. DFO 63

Issue **Contaminants and Toxicity**

Request The naphthenic acid column has a couple of relatively high numbers. How do these compare with the toxicity of commercial mixtures of naphthenic acids?

Response Microtox data are not available for commercial naphthenic acid mixtures for comparison with the porewater samples in which naphthenic acid concentrations were elevated (Table D5-5). Based on recent test results for CT water produced by Suncor, concentrations of naphthenic acids below 20 mg/L are unlikely to be toxic to bacteria. For example, CT water with a naphthenic acid concentration of 78 mg/L was tested during the most recent Suncor studies, and results for all toxicity tests matched well with those of previous tests of CT waters. The 22.7% dilution of CT water (corresponding to a naphthenic acid concentration of about 18 mg/L) caused 25% light reduction in the Microtox test, which represents marginal toxicity. However, as CT water might contain other toxicants that likely contributed to the observed toxicity, the effect of naphthenic acids alone on light inhibition would likely be less than the 25% measured. Therefore, the relatively high concentrations referred to by the reviewer (16 and 17 mg/L) are unlikely to be toxic to aquatic organisms.

Question No. 7.0

Shell No. DFO 64

Issue **Contaminants and Toxicity**

Request Tables D5-2, D5-6 and D5-7 - These tables treat organic analytes as groups and do not identify which individual compounds made up the group totals. These data will become important in the future for trend studies and so it is not acceptable to publish only group totals.

The tables should be expanded to list all the analytes one by one.

Response Statement acknowledged. However, group totals were shown, as most samples contained non-detectable levels of individual PAHs, phenolics and volatile organics.

Attachment 1 contains individual substance concentrations.

Question No. 7.0

Shell No. DFO 65

Issue **Contaminants and Toxicity**

Request Most water mercury levels were below detection of 0.0001 mg L^{-1} but on several occasions mercury was listed as 0.0001 mg L^{-1} and on one occasion it was 0.0002 mg L^{-1}. From table D5-1 we see that US EPA guidelines for mercury are 0.0024 and 0.000012 mg L^{-1} for acute and chronic effects respectively. The CCME guideline is 0.1 μg L^{-1} (0.0001 mg L^{-1}). From Table E5-4 it is apparent that there is another guideline of 0.00014 mg L^{-1} for the protection of human health.

Does Alberta have provincial PAH guidelines?

Response It is assumed that the reviewer intended the question to read "mercury", not "PAH" guideline. Alberta does have a mercury guideline of 0.0001 mg/L, which was applied in the modeling as a chronic guideline according to AEP (1995) and AEP (1996). The US EPA acute value for mercury was also used.

Question No. 7.0

Shell No. DFO 66

Issue **Contaminants and Toxicity**

Request These values suggest the real possibility of a mercury problem in these waters. The question is whether or not that has anything to do with the oil sands operations and Shell in particular.

Response High mercury levels relative to water quality guidelines in Alberta are not uncommon. Alberta has fish consumption warnings on 17 basins in Alberta as a result of mercury levels in fish. There does not appear to be any evidence that the oil sands operations are contributing to increased mercury levels in this reach of the Athabasca River. Based on the water quality data available for mercury, modeling predictions indicate that oil sands releases in general dilute background values of mercury in the Athabasca River.

Question No.	**7.0**
Shell No.	**DFO 67**
Issue	**Contaminants and Toxicity**
Request	There is no mention of the mercury content of bitumen but surely that information must be available. What is the mercury content of bitumen?
Response	Information on trace metal content in bitumen is limited. Jacobs, (1982) found a mercury concentration of 31.5 ng/g in Athabasca bitumen.

Question No.	**7.0**
Shell No.	**DFO 68**
Issue	**Contaminants and Toxicity**
Request	It is likely that the NRBS or some subsequent study did work on mercury in fish. Perhaps a summary of that work should be included here.
Response	Donald et al (1996) measured mercury in fillets or liver of fish species in the Athabasca River under the Northern River Basin Study (NRBS). The decreasing order for concentrations of mercury in fish, according to these studies, was walleye > goldeye > northern pike > longnose sucker > mountain whitefish. Levels of mercury exceeded human consumption guidelines for 25% of the walleye captured in the Athabasca River. However, it was noted that mercury levels have been relatively stable since the 1980s (Donald et al 1996).

Question No.	**7.0**
Shell No.	**DFO 69**
Issue	**Contaminants and Toxicity**
Request	Page E5-9 and E5-10 – The use of Toxicity Units (TU) is confusing. These units have been around for quite some time but are rarely seen now except in Golder's EIA documents.
Response	The TU approach has been used as per AEP (1995, 1996), Environment Canada. Guidance (1996), and US EPA (1991).

Question No.	**7.0**
Shell No.	**DFO 70**
Issue	**Contaminants and Toxicity**

Request

The calculation is explained on page E5-9 as Toxic Units = 100/LC-50. Usually toxic units are defined as Toxic Units = concentration in exposure water/LC-50. In this document, the concentration in the exposure water has been replaced by 100 and so it is assumed this substitution implies that the results are derived from tests with undiluted, 100% sand and seepage water or 100% CT water. Is this correct?

Response

Units are derived from dose response (e.g., IC_{25}=48%). It is a simple inverse that is calculated so that TUs can be modeled like any other substance concentration.

Question No.	**7.0**
Shell No.	**DFO 71**
Issue	**Contaminants and Toxicity**

Request

When the TU figures are converted back to toxicities one gets a TUa for sand seepage as TUa = 100/LC-50, then 2.3 = 100/LC-50 which means that the LC-50 must have been (100/2.3) = 43. It is assumed that this means that the LC-40 for sand seepage water was 43% and this has no more meaning than a TUa of 2.3.

Is this what Shell intends?

Response

The reviewer's calculations are correct and it is what Shell intends.

Question No.	**7.0**
Shell No.	**DFO 72**
Issue	**Contaminants and Toxicity**

Request

Appendix VII, Table VII-1 and VII-2 - Looking at Table VII-1 in Appendix VII, one does not find an LC-50 of 43% but rather the following ranges. Consequently, it is not clear how the TU figures were derived. The meaning would be clearer if both their TU values and the LC-50 values were tabulated. The key information is missing here, and that is the nature of the dosage-response relationship. It would be helpful if the document showed a graph of the complete dosage-response data for both sand seepage water and CT water for each type of exposure and test organism. It is not clear what can be learned from this except that both sand seepage water and CT water are mildly toxic acutely and probably to about the same degree.

Response

The LC_{50} value of 43% corresponds to a test result using rainbow trout (TUa=2.3). LC_{50} and IC_{25} test results used to define TID and CT water toxicity, as well as their respective TUa and TUc values, are listed in Attachment 2.

Attachment 3 contains the dose-response curves requested.

AEP guidance was used to develop EIA methodology for the use of toxicity data.

The results indicate no potential for instream toxicity using worst case assumptions. The acute and chronic guidelines against which modeled results were composed are based on no toxicity occurring.

Question No. 7.0

Shell No. DFO 73

Issue Contaminants and Toxicity

Request

Given that discharges/leakages will probably occur slowly over a long time, the chronic data are probably more important than the acute data. In the column for chronic toxicity one notes a TUc value of 6.3 for sand seepage water, implying an LC-50 of 100/6.3 = 15.9 (assuming the IC-50 is substituted for the LC-50 in the chronic tests). Hence the toxicity is 2-3 times greater (15.9% vs. 43%) under chronic exposure than under acute exposure conditions. This suggests that there are chronic effects not detected by acute exposures. It is not apparent where the TUc value of 6.3 came from in looking at Table VII-1, but the three chronic tests were the 72-hr *Selanastrum* growth test, the 7-day *Ceriodaphnia* reproduction test and the 7-day fathead minnow growth test. For sand seepage water, these tests produced IC-50 values of 92 - >100%, 22 - 52%, 62.5% and 29 - 52% respectively.

Can the derivation of the TUc of 6.3 be explained.

Response

The TUc and TUa values and associated IC_{25} and LC_{50} values cannot be interchanged. Further, chronic toxicity values were derived using IC_{25}, not IC_{50}, test results. The TUc of 6.3 corresponds to the lowest IC_{25} reading observed with *Ceriodaphnia dubia.*

Question No. 7.0

Shell No. DFO 74

Issue **Contaminants and Toxicity**

Request

The LOEC value for minnows exposed to sand seepage water was 6.25-12.5%, a range lower than that for the IC-50 but the same as that for the IC-25. This suggests that there were subtle effects on the growth of the fish but that the dosage-response relationship must be very steep since the range for no effect was so similar to that for the IC-25. It is noted that the NOEC value for fathead growth was <6.25 meaning, one assumes, that 6.25% was the lowest concentration tested and that there was some effect on growth at that concentration. Consequently, we know there was an effect but we do not know how low a concentration would produce it.

This test should be repeated using lower concentrations to find out where the NOEC really is.

Response

Comments acknowledged. Further chronic toxicity testing is proceeding under RAMP, the intended joint industry fish health study and individual company monitoring programs. Further testing will be done with concentrations that will most accurately bracket expected NOEC values.

Question No. 7.0

Shell No. DFO 75

Issue **Contaminants and Toxicity**

Request

With regard to effects on the fish, several studies have documented that there are already effects evident on the fish in the lower Athabasca River. These studies should be familiar to the consultants. The problem with the existing data is they cannot separate effects of existing industrial installations from natural geological effects of the erosion of the oil sands. Results have been published in one of the Northern River Basins Study reports (Lockhart & Metner, 1996). There were indications of induction of liver enzymes and delays in sexual maturation in fish from the reach downstream from Fort McMurray.

It is surprising that these and other studies were not mentioned in the sections reviewed.

Response

There is ample evidence of mixed function oxidase (MFO) induction in fish in the oil sands area, indicating exposure to a combination of natural conditions and industrial discharges (Lockhart and Metner 1996, Golder 1996).

However, there is insufficient evidence of fish health effects in the Athabasca River. Lockhart and Metner (1996) found indications that the frequency of immature burbot collected in the lower Athabasca River in NRBS studies is lower than expected. However, this finding has not been confirmed (Lockhart and Metner 1996). In fish health studies for the Steepbank Mine, some changes in serum glucose were noted compared to reference data but sample sizes were low or reference data were from a different year (Golder 1996).

Shell, with Syncrude and Suncor, are funding two fish health studies. Fish health parameters will be measured in fish collected as part of the RAMP program and the health of fish exposed to CT waters will be assessed in the laboratory.

Fish health parameters will be measured in fish collected as part of the RAMP program from the Athabasca River and tributaries to the Athabasca, including the Muskeg River. These parameters will include gonadal somatic index (GSI), fecundity, condition factor and age-to-maturity. This field fish health information will be used in conjunction with results of previous and future laboratory studies to provide a weight-of-evidence approach to determining impacts on fish populations and fish health.

These studies will be conducted before the Muskeg River Mine Project is operational, to ensure that results can be used to design mitigation and future monitoring plans, if necessary. These studies will include three elements:

- laboratory exposures of fish to CT water (i.e., fish health studies that will include an analysis of tissue residues in fish)
- chemical characterization of CT water used for the tests
- toxicity testing at different trophic levels

Laboratory Exposures of Fish to CT Water:

The overall approach would be very similar in design to the studies already carried out on Tar Island Dyke (TID) water and upgrader outfall wastewater from Suncor's Lease 86/17 operation (HydroQual 1996a, 1996b). Studies would include fish health and challenge tests, which are designed to measure potential effects on the general health and condition of fish following prolonged exposure to wastewaters. The study design includes exposures of about one month in duration and a dilution series representative of concentrations predicted to occur in the receiving environment. The following fish health indicators will be examined:

- survival and growth of rainbow trout juveniles and sac fry (i.e., fry transition from sac to swim-up phase) and walleye juveniles (if available)
- suborganismal indicators: mixed function oxidases, blood chemistry, hematology, DNA adducts
- whole organism indicators: liver size, fat content, condition factor, growth, gross pathology, histopathology, embryo survival, embryo deformities, swimming stamina, resistance to bacterial infection
- tissue analysis for metals and PAHs (whole fish)

Chemical Characterization of Wastewaters:

In conjunction with the fish health studies, a representative number of samples of CT water will be submitted for analyses of oil sands related parameters and routine water quality parameters. The analyses will be comparable to existing information on CT water chemistry.

Trophic Level Toxicity Testing:

Samples of the CT waters collected for the fish health studies will be tested as follows:

- bacterial luminescence (Microtox)
- algal growth inhibition
- survival of *Daphnia magna*
- survival and reproduction of *Ceriodaphnia dubia*
- survival and growth of fathead minnows
- survival of rainbow trout

The chemistry, fish health data and toxicity test information will be interpreted together. The complete data set will be evaluated for consistency (i.e., the chemistry, toxicity and health data should provide complimentary, not contradictory information). The new data will also be added to the existing chemistry and toxicity data on CT water to enhance the existing information regarding the potential for environmental impacts from CT water.

Question No. **7.0**

Shell No. **DFO 76**

Issue **Contaminants and Toxicity**

Request Tables E5-4, E5-5, E5-7 - These tables include only some elements and not the organic compounds of greatest interest. All the projected exceedences are attributed to natural causes. Probably these volumes contain mass balance data somewhere but this section seems a logical place to list the projected loadings attributable to the proposed operation. Can this be derived by taking "Project (existing + incremental)" and subtracting either "Upstream Fort McMurray" or "Predicted LSA"?

A table which lists projected monthly, yearly and cumulative project contributions substances by substance should be provided.

Response EIA Volume 3, Part 1, Tables E5-4, E5-5 and E5-7, include only the substances that exceed regulatory guidelines. Tables in EIA Volume 3, Part 2, Appendix V, contain predictions for all of the substances screened. These Appendix V tables contain predictions for mean open water (summer) and 7Q10 (winter) and cumulative contributions. EIA Volume 4, Section F5, Section G5, and Appendix XII, contain additional cumulative information.

Question No. **7.0**

Shell No. **DFO 77**

Issue **Contaminants and Toxicity**

Request Table E5-6 - This seems to be the only table in which any organic compounds have been included. It is not clear what is included in the "benzo(a)anthracene group" or the "benzo(a)pyrene group". Usually benzo(a)anthracene and benzo(a)pyrene are measured separately as individual compounds. If these were measured as a group of similar compounds then it questionable whether any water quality guidelines apply. The major environmental question for these organic compounds is probably not their concentrations in water but rather their concentrations in sediments.

What are the projected concentrations in the receiving sediments?

Response

Predicted levels of naphthenic acids and other organic compounds are described in EIA Volume 3, Part 2, Tables V-5 to V-12 and in EIA Volume 4, Tables XII-1 to XII-12.

Compounds were grouped and assessed according to methods described in Golder (1996) (see groupings summary in Attachment 4).

Projected PAH accumulation in sediments was not assessed in this EIA, because of the lack of pathways for these compounds to leave the development area. Seepage and end pit lake outflow are the main pathways for PAHs to reach surface waters, and both are unlikely to contribute measurable amounts of PAHs. Seepage through the ground and settling in the end-pit lake are expected to remove suspended sediments from reclamation waters reaching surface waters and, thus, would remove nearly all of the associated PAHs.

However, Shell recognizes the need for additional information on PAHs and is currently participating in a sediment monitoring program (a component of RAMP). Shell has proposed to analyze PAHs in the water column, suspended sediments and bottom sediments at all RAMP monitoring stations using ultra-low PAH detection limits, to better characterize baseline levels and will also measure PAHs in reclamation waters produced by pilot-scale trials. See also the response to AEP 35.

An assessment of PAH sediment loading will be considered if future analyses of Shell's reclamation waters indicate the potential for PAH loading at greater than expected rates from the Muskeg River Mine Project.

Question No. **7.0**

Shell No. **DFO 78**

Issue **Contaminants and Toxicity**

Request

Table E5-9 - What is a "WET Guideline"? Apparently the units in this table (and in tables E5-10, E5-11 and E5-12) are TUa and TUc. Is the definition of TU the same here as it was in Vol. 3, Page E5-9 and E5-10?

Response

The whole effluent toxicity (WET) guideline is discussed in AEP (1995), federal toxicity guidance (Environment Canada, 1996), and US federal guidance (US EPA, 1991).

The definition is the same.

Question No.	**7.0**
Shell No.	**DFO 79**
Issue	**Contaminants and Toxicity**
Request	If one applies the same calculation the TU = 100/LC-50, then the results do not seem to make sense.
Response	TU is used so that it can be modeled. Once TU is calculated, it is treated like any other chemical concentration. The reviewer's calculations are correct.

Question No.	**7.0**
Shell No.	**DFO 80**
Issue	**Contaminants and Toxicity**
Request	For example, the TU for acute toxicity is given as 0.0006 for the predicted Local Study Area (LSA). Substituting this into the definition, one gets 0.0006 = 100/LC-50. Hence the LC-50 = 100/0.0006 = 166,667. What units were used for the LC-50 which went into the calculation of TU?
Response	The units were "%" e.g., 100/(LC_{50}=98%).

Question No.	**7.0**
Shell No.	**DFO 81**
Issue	**Contaminants and Toxicity**
Request	Whatever the TU implies, the "Predicted at LSA" was 0.0006 and the "Project (existing plus incremental)" was 0.003 which indicates that the LC-50 decreased from 166,667 (concentration units?) to 33,333 (concentration units?) as a result of the project. That is, the toxicity will increase several fold as a result of the project. 81.1 The guidelines are stated to be 0.3 TUa for acute toxicity and 1.0 TUc for chronic toxicity. Where did these guideline TU values come from?
Response	81.1 See the response to DFO 78.

Request 81.2 Were they published as TU values or as exposure concentrations?

Response 81.2 They are published as TU values which are fundamentally the same thing as exposure concentrations.

Question No. 7.0

Shell No. DFO 82

Issue **Contaminants and Toxicity**

Request

(The TU translates) to toxicities of 100/0.3 = 333 and 100/1 = 100 concentration units respectively and so apparently the increases due to the project are well below the guideline TU values. This is a surprising calculation. The new pulp and paper regulations aim at releases that are not toxic at all in acute fish toxicity tests.

Is increased toxicity in discharges acceptable in this type of operation?

Response

The acute value is 333% because it assumes dilution to reach a completely non-toxic state from an LC_{50} = 100%. As the reviewer might be aware, the federal pulp and paper regulations say LC_{50}=100% (or equivalent thereof), which is clearly not non-toxic. It is assumed that no operational discharges would be allowed if they were acutely toxic by this definition. This is also an Alberta provincial requirement.

Question No. 7.0

Shell No. DFO 83

Issue **Contaminants and Toxicity**

Request

Pages E-32 to E-34 - Apparently there are considerable data on sediments of the Athabasca River from studies by Brownlee et al. but no data on PAHs in the Muskeg River. Athabasca River data should be tabulated along with samples obtained the Muskeg River and have them analyzed.

There is no comment about the sites in the Athabasca River; were they sites of sediment deposition?

Response

Sediment PAH data available for the Muskeg River basin consists of the data presented in EIA Volume 2, Table D5-9. Relative to the Athabasca River samples, Muskeg River samples were characterized by higher TOC (2 to 4.5 % versus. 0.5 to 2.3%, Muskeg River and Athabasca River, respectively), higher hydrocarbon content (3,400 to 5,700 µg/g versus. 400 to 2,200 µg/g), lower levels of most major and trace metals and higher total PAH levels (1.7 to 3.9 µg/g versus. 0.1 to 4.3 µg/g, with most values below 1.5 µg/g in the Athabasca River).

Question No. 7.0

Shell No. DFO 84

Issue **Contaminants and Toxicity**

Request

The authors present the argument that biological effects have not been demonstrated; this may not be the case (see W.L. Lockhart and D.A. Metner. 1996). These effects have been demonstrated, the problem is to figure out whether they are caused by development or by the natural state of the river. It is not clear which is the study cited by Crossley, but the question is not so much to compare the Athabasca River with other rivers but to compare it with itself prior to oil sand mining. That can only be done through archived samples if they exist or by cores from areas of sediment accumulation.

The only core studies seen were inconclusive. They should be done again.

Response

The study by Crosley cited in the EIA is NRBS Report 106.

To our knowledge, there are no archived samples from the Athabasca River from before oil sands development, which precludes a before-after comparison. Comparisons with other rivers were made to evaluate whether levels of PAHs in sediments of the Athabasca, which flows through an extensive oil sands area, are substantially different from sediments of other northern rivers which are not affected by oil sands.

In addition, Shell is recommending a review of the existing literature on sediment coring in the region to assess PAH levels during the pre-development oil sands period compared to the post-development period. If this review provides evidence of increased PAH levels as a result of oil sands developments, implementing further field programs in the Peace Athabasca Delta or Lake Athabasca would be considered.

Question No. 8.0

Shell No. DFO 85

Issue **Fish Health Tainting**

Request

The statement that PAH concentrations are likely to be below those which produce off-flavors in fish because CT water has lower levels of organic compounds that TID water and hence tainting is not expected from CT waters is not supported.

Reference to previously conducted studies needs to (be) validated as they were previously called into question by DFO for the Suncor and Steepbank Mine Projects.

Response

Shell, in conjunction with Suncor and Syncrude, will conduct studies on the potential effects of CT water on fish tainting. This study will be conducted before the Muskeg River Mine Project is operational, to ensure that results can be used to design mitigation and future monitoring plans, if necessary.

Tainting studies will be conducted using exposure tanks in a laboratory facility to be established in Fort McMurray. Rainbow trout will be exposed to a series of dilutions of CT water that are representative of a range of possible conditions in the field (e.g., 10%, 1%, 0.1% and 0.01%). After a 10-day exposure period, a number of fish will be removed and processed for assessment of tainting.

Taste panels will consist of Fort McMurray and region residents who have been trained in the testing protocol. This procedure involves the following steps:

- initial recruitment of 30 to 40 people.
- selection of participants based on ability to detect taint.
- further training of selected participants (20 total).
- selection of panelists for the taint assessment (10 people).

The fish tainting protocol that will be used for this study was written by HydroQual Laboratories Ltd. and reviewed by Roberta York of the Department of Fisheries and Oceans. The test was designed to determine the presence and intensity of taint. This procedure will also comply with ASTM Method E 1810-96 and the Pulp and Paper EEM: Recommendation for Cycle 2 (Environment Canada 1997).

Question No. **8.0**

Shell No. **DFO 86**

Issue **Fish Health Tainting**

Request

Under Section E6.7.4 it is stated that there is a moderate amount of certainty in the prediction regarding fish tainting. It is not clear what moderate amount means.

If there are any residual concerns these would require additional investigation and or monitoring.

Response

See the response to DFO 85.

Question No.	**8.0**
Shell No.	**DFO 87**
Issue	**Fish Health Tainting**
Request	Details of any proposed investigations or monitoring programs should be disclosed.
Response	See the response to DFO 85.

Question No.	**8.0**
Shell No.	**DFO 88**
Issue	**Fish Health Tainting**
Request	What impact will the development have on the use of fish from the Muskeg River by man?
Response	Biocaccumulation of chemicals in fish tissue and the risk to people's health was described in EIA Volume 3, Part 1, Section E12.6.1. Chemicals in fish tissue from fish from both the Muskeg and Athabasca Rivers will be monitored as part of RAMP.

Question No.	**8.0**
Shell No.	**DFO 89**
Issue	**Fish Health Tainting**
Request	Has the use of this resource been quantified?
Response	The use of the resource has been discussed in EIA Volume 2, Section D14.3.7. Very little quantitative information exists on the use of the fish in the region. The Muskeg River and Jackpine Creek are important angling areas and are also used for subsistence fishing. No commercial fishing exists on the Muskeg River and Jackpine Creek. Some commercial fishing takes place on the Athabasca River. Most anglers on the Athabasca River practice catch and release because of a concern about the safety of consuming the fish.

Question No. 9.0

Shell No. DFO 90

Issue **Acidifying Depositions**

Request

The potential implication of acidifying emissions on the aquatic environment needs to be further clarified. The magnitude and degree of concern for this has been rated as high to moderate (E2-51). It is also indicated that this phenomenon will addressed in part through the RAMP and RAQCC monitoring programs.

As such, the degree of concern stated as "undetermined" may be appropriate until such time as this potential impact of this issue is resolved.

Response

The degree of concern stated in each section of the EIA might differ for the same issue, depending on the impact classification system adopted by each EIA component. There is some uncertainty associated with the issue of acid deposition that can only be eliminated by further monitoring and research, as agreed upon by AEP and the oil sands companies.

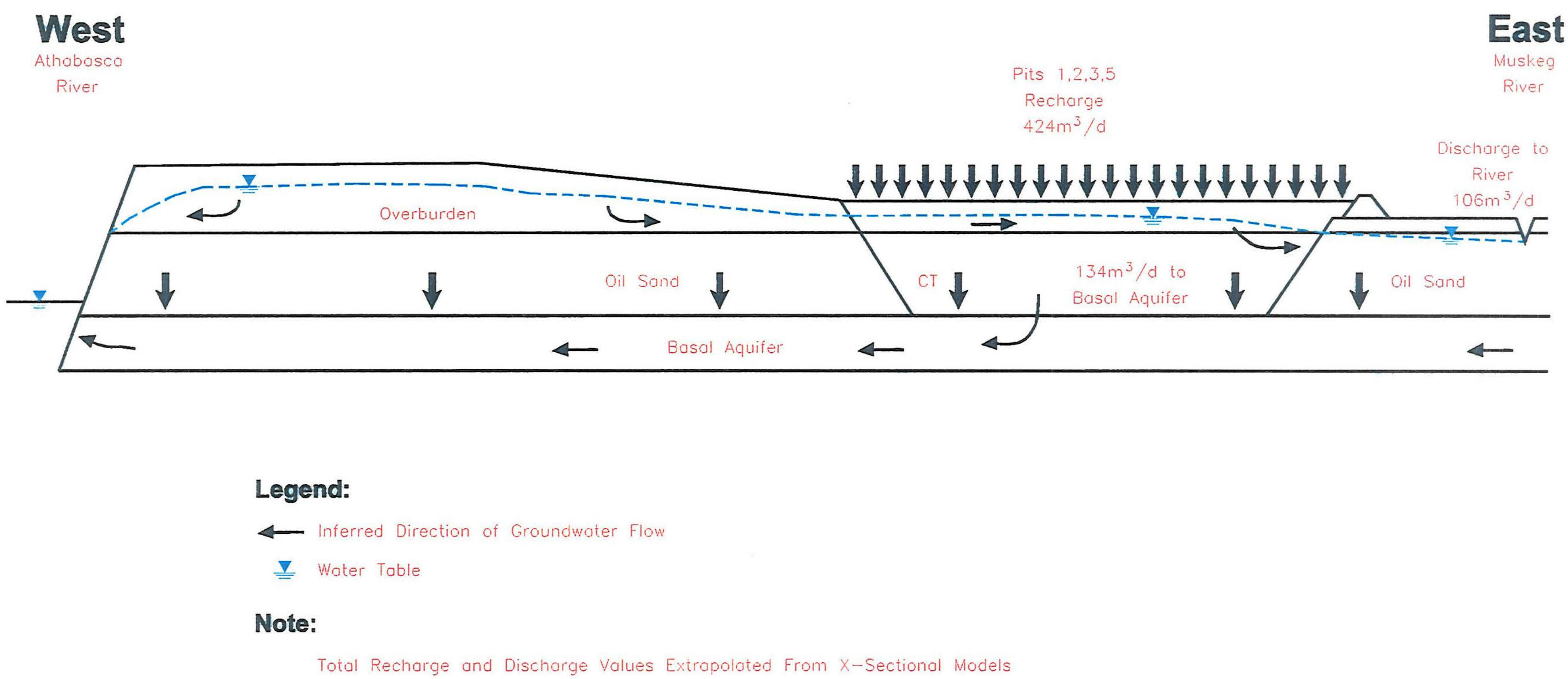


Figure 1: Potential Movement of CT Waters in Reclaimed Landscape (Schematic Hydrogeologic Cross Section for Far Future

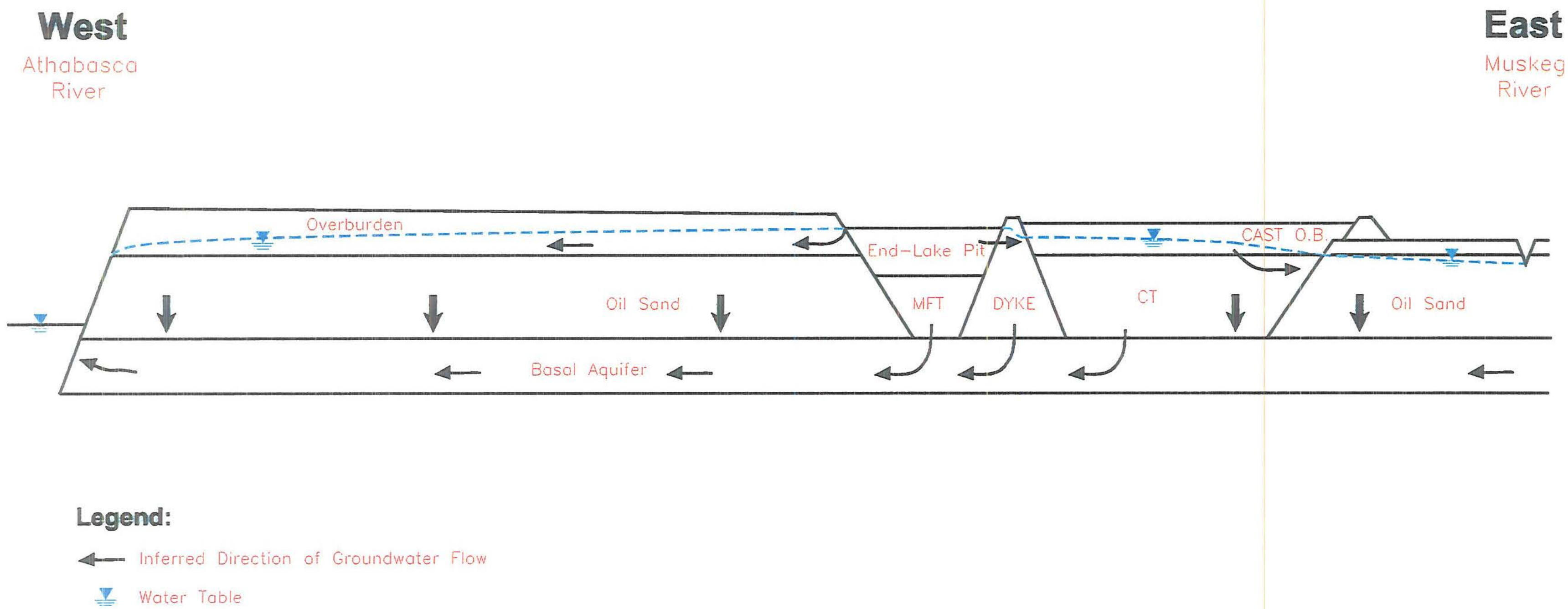


Figure 2: Potential Movement of Seepage in Reclaimed Landscape

Figure 3: Mean Annual Kearl Lake Water Balance (Schematic)

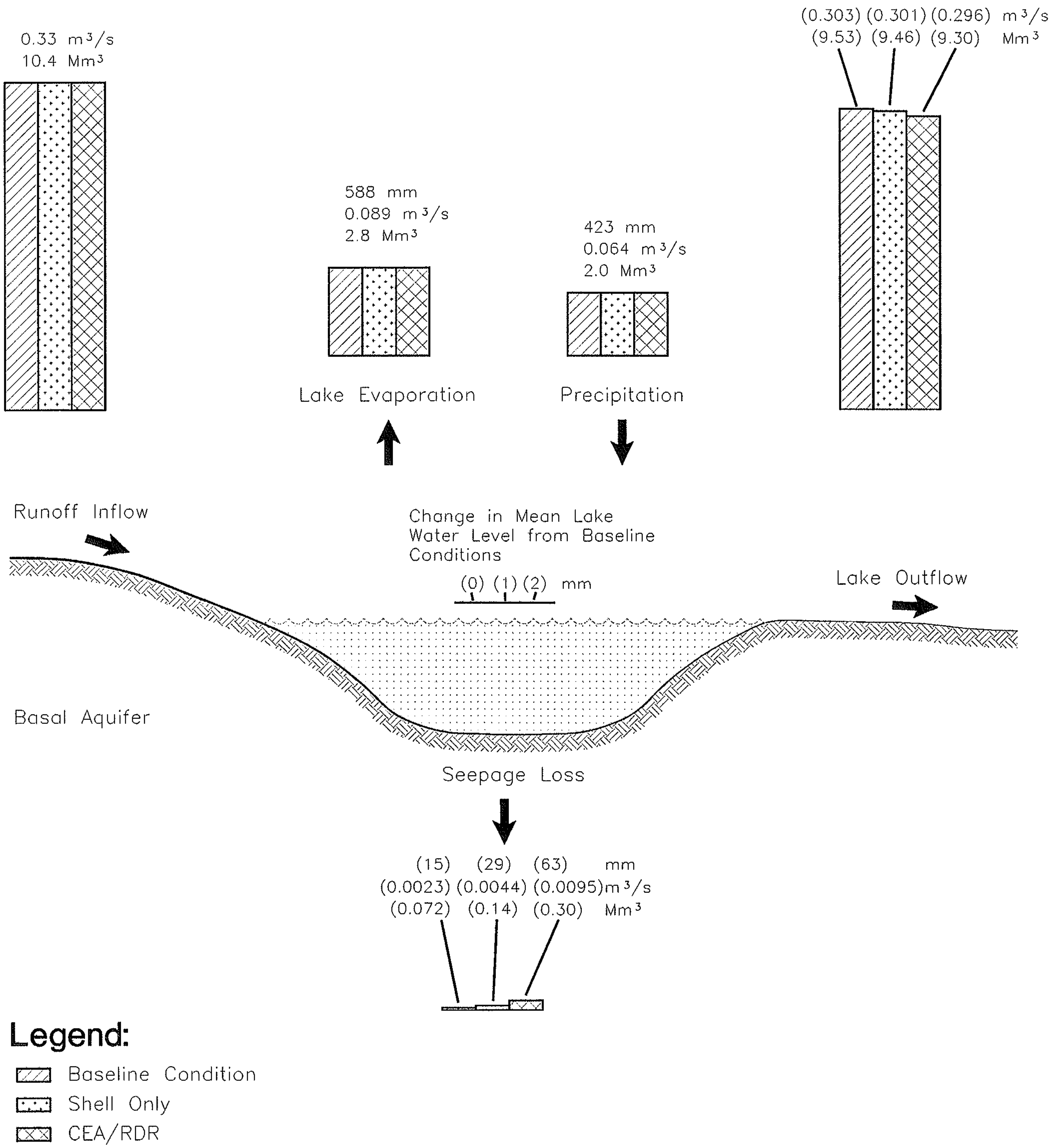


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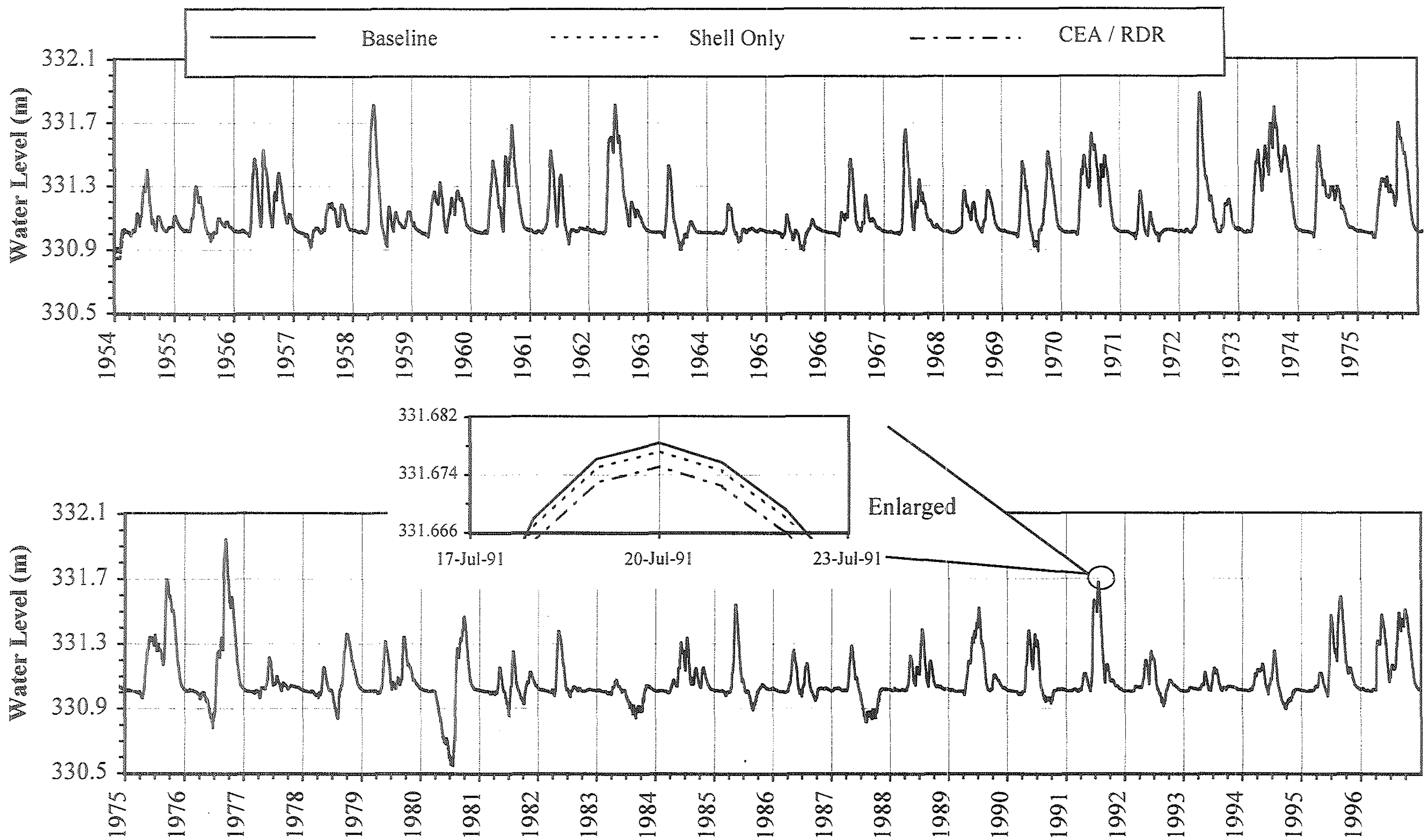
Figure 4: Comparison of Kearl Lake Water Levels for Baseline, Shell Only and CEA/RDR



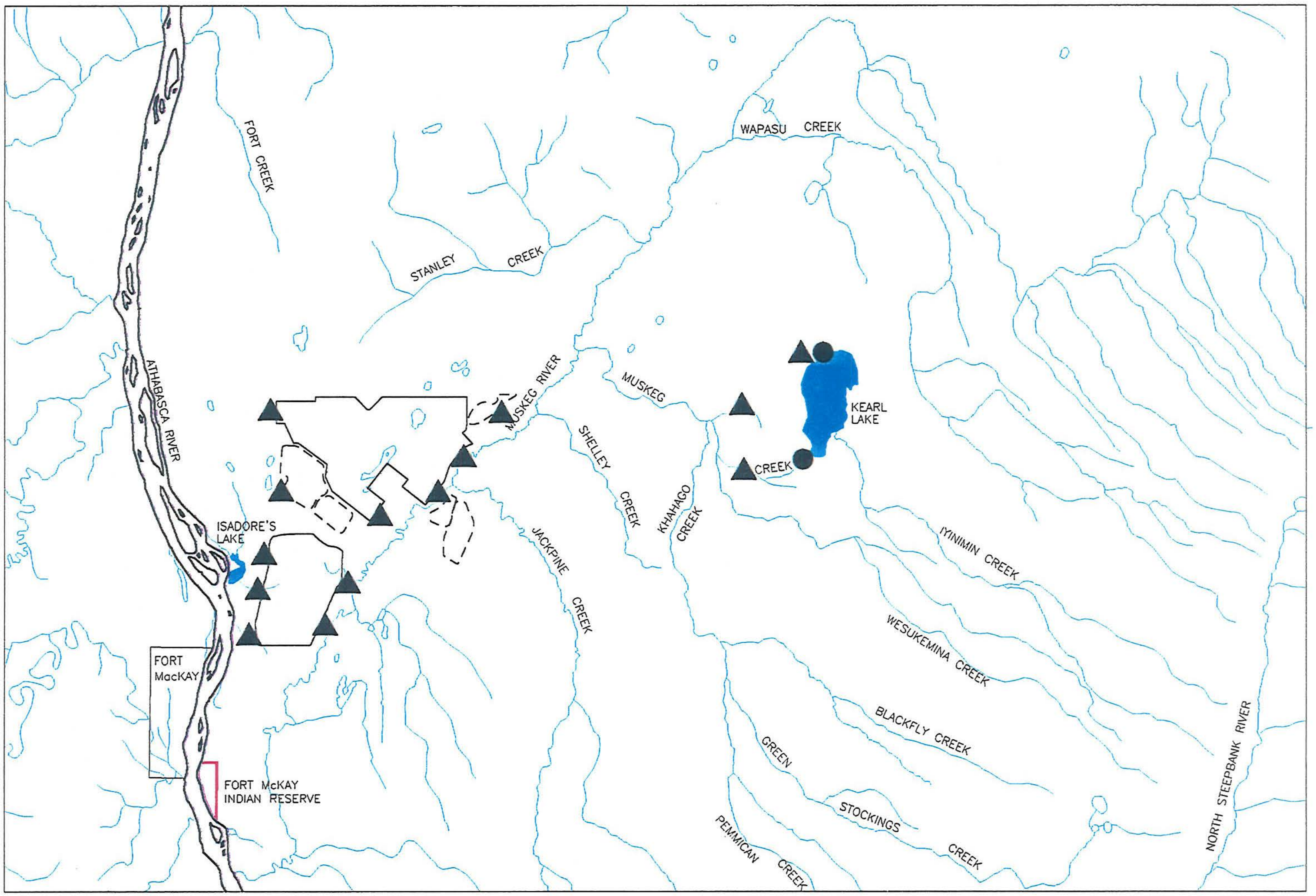
NOTE

i) Figure shows the effects of Shell and CEA / RDR operations on simulated baseline Kearl Lake water levels from 1954 to 1996.

ii) The water level hydrographs appear to be overlapping because the differences between Kearl Lake water levels for Baseline, Shell only and CEA / RDR are negligible.

iii) The enlarged figure showing the water level hydrographs from 17 to 23 July 1991 is an example to show the small differences between Kearl Lake water levels for Baseline, Shell only and CEA / RDR.

Figure 5: Conceptual Monitoring Network to Address CT/Sand Seepage and Kearl Lake Water Balance Concerns



Legend:

- ● Lake Level and Outflow Monitoring Station
- ▲ Ground Water Monitoring Station

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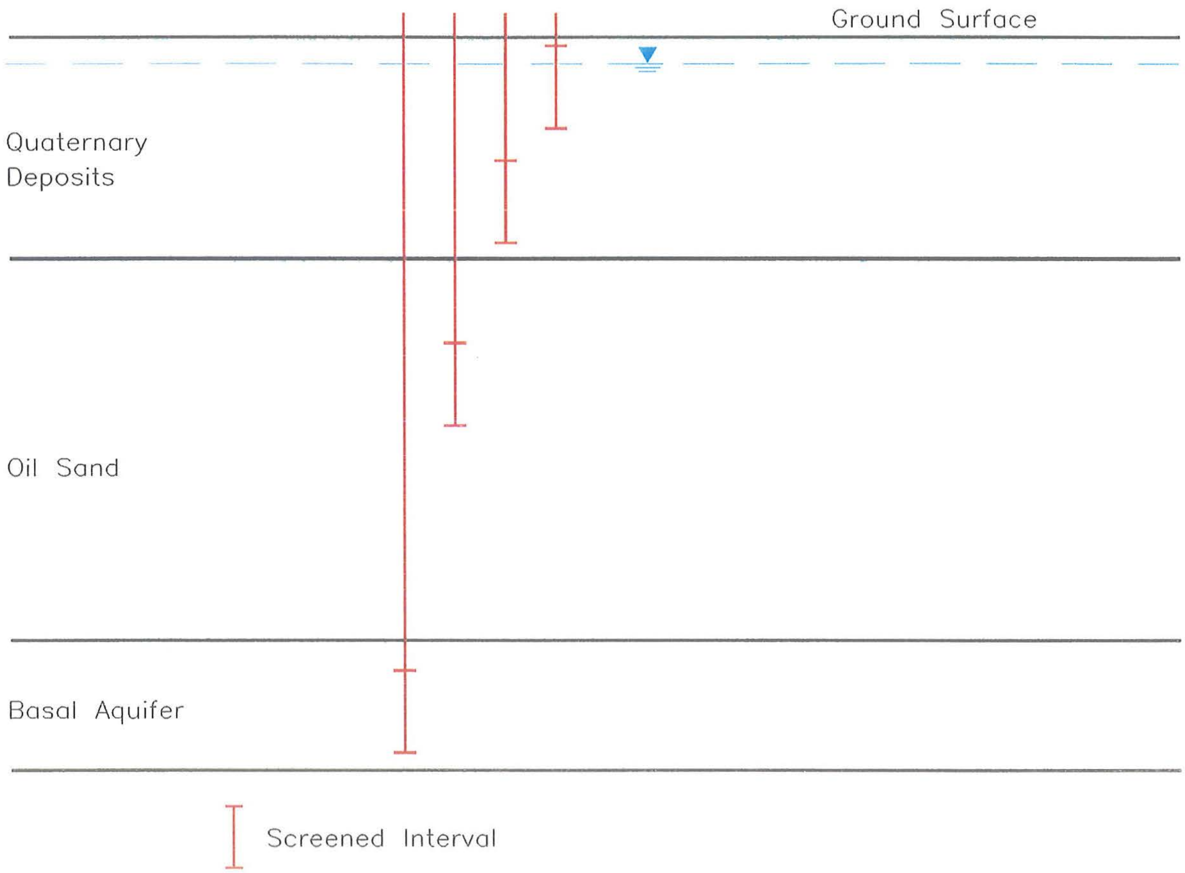
Figure 6: Typical Piezometer Nest for Groundwater Monitoring Program (Schematic)



Locations:

- Between Mine Pits and Muskeg River
- Between Sand Storage Area and Muskeg River
- Between Sand Storage Area and Athabasca River/Isadore's Lake
- Adjacent to Overburden Dump Areas
- NE Corner of Lease 13 (Nearest Kearl Lake)
- Immediately Adjacent to Kearl Lake

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Table G4 - 10 Cumulative Effects of the Oil Sands Developments in the Muskeg River Basin on the Muskeg River Flows at Node S16

Year	Existing Drainage Area (km^2)	Future Area (km^2)				Mean Annual Seepage and Dewatering Discharges (m^3/s)										
						Muskeg Drainage[a]		Overburden Dewatering[a]		Perimeter CT Seepage[b]		Upward CT Flux[b]		Sand Storage Seepage[b]		
		Undisturbed Area	Reclaimed Area[d]	Closed Circuit Area	Total Drainage Area	Aurora Mines	Other Mines[f]	Aurora Mines[b]	Other Mines[f]	Aurora Mines	Other Mines[f]	Aurora Mines	Other Mines[f]	Aurora Mines	Other Mines[f] Collected In Ditches	Other Mines[f] Not Collected In Ditches
2007	1393	1308	2.9	60.5	1333	0.306	0.078	1.037	0.055	0	0	0	0	0	0	0.013
2020	1393	1206	8.6	167.2	1226	0.108	0.083	0.219	0.072	0	0	0	0	0	0	0.034
2030[e]	1393	1136	36.7	202.9	1184	0.109	0.083	0.189	0.067	0	0.0001	0	0.04	0.338	0	0.030
Far Future	1393	1127	240.6	0.0	1367	0	0	0	0	0.066	0	0	0	0.338	0.057	0.021

Year	Streamflow Discharge (m^3/s)																	
	Annual Mean Discharge			Mean Open-Water Discharge[c]			Mean Ice-Cover Discharge[c]			Open-Water 7Q10 Discharge			Ice-Cover 7Q10 Discharge			Mean 30Q Discharge		
	Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference
2007	5.28	6.55	24%	8.21	9.80	19%	1.11	2.11	90%	0.281	2.197	682%	0.052	1.100	2015%	0.225	1.266	463%
2020	5.28	5.32	1%	8.21	8.25	1%	1.11	1.26	14%	0.281	1.035	268%	0.052	0.300	478%	0.225	0.461	105%
2030[e]	5.28	6.12	16%	8.21	9.58	17%	1.11	1.57	42%	0.281	2.598	825%	0.052	0.643	1136%	0.225	1.151	412%
Far Future	5.28	5.29	0%	8.21	7.96	-3%	1.11	1.49	34%	0.281	0.738	163%	0.052	0.529	918%	0.225	1.036	361%

[a] Muskeg drainage and overburden dewatering at the Muskeg River Mine, Lease 13 East Mine and Kearl Mine will occur during the open-water season.
[b] Overburden dewatering at Aurora North and South, perimeter CT seepage, CT upward flux, sand storage seepage will occur throughout the year.
[c] The "open-water" season is defined as the period from mid-April to mid-November inclusive. The "ice-cover" season is defined as the period from mid-November to mid-April
[d] Reclaimed area includes end pit lakes and wetlands.
[e] Mean annual mature fine tailings (MFT) transfer rate of 0.618 m3/s from the tailings pond to the end pit lake at the Muskeg River Mine was added to each future open-water surface runoff discharge parameters for year 2030.
[f] Other mines include Muskeg River Mine, Lease 13 East Mine, and Kearl Mine.

4 June, 1998

ATTACHMENT 1

DETAILED PAH, PANH, PHENOLICS AND VOLATILE ORGANICS RESULTS

Includes:

- Surface Waters
- Pore Water
- Sediment
- Operational and Reclamation Waters

		Sample collected near Tar Island Dyke in Fall of 1995						
		et. bk., top of TID	wt. bk., start of TID	wt. bk., by Ship. Lk.				
Parameter	Units	data	data	data	min	median	max	count
Target PAHs and Alkylated PAHs								
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted dibenzothiophen(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra(	ppb	< 0.04	< 0.04	0.04	< 0.04	< 0.04	0.04	3
C3 Subst'd phenanthrene/anthra(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanthr	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Target PANHs								
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenolics								
Phenol	ppb	-	-	-				
o-Cresol	ppb	-	-	-				
m-Cresol	ppb	-	-	-				
p-Cresol	ppb	-	-	-				
2,4-Dimethylphenol	ppb	-	-	-				
2-Nitrophenol	ppb	-	-	-				
4-Nitrophenol	ppb	-	-	-				
2,4-Dinitrophenol	ppb	-	-	-				
4,6-Dinitro-2-methyl phenol	ppb	-	-	-				
Volatile organics								
Acetone	ppb	-	-	-				

		Sample collected near Tar Island Dyke in Fall of 1995						
		et. bk., top of TID	wt. bk., start of TID	wt. bk., by Ship. Lk.				
Parameter	Units	data	data	data	min	median	max	count
Acrolein	ppb	-	-	-				
Acrylonitrile	ppb	-	-	-				
Benzene	ppb	-	-	-				
Bromodichloromethane	ppb	-	-	-				
Bromoform	ppb	-	-	-				
Bromomethane	ppb	-	-	-				
2-Butanone (MEK)	ppb	-	-	-				
Carbon disulfide	ppb	-	-	-				
Carbon tetrachloride	ppb	-	-	-				
Chlorobenzene	ppb	-	-	-				
Chloroethane	ppb	-	-	-				
2-Chloroethyl vinyl ether	ppb	-	-	-				
Chloroform	ppb	-	-	-				
Chloromethane	ppb	-	-	-				
Dibromochloromethane	ppb	-	-	-				
Dibromomethane	ppb	-	-	-				
1,2-Dichlorobenzene	ppb	-	-	-				
1,3-Dichlorobenzene	ppb	-	-	-				
1,4-Dichlorobenzene	ppb	-	-	-				
cis-1,4-Dichloro-2-butene	ppb	-	-	-				
trans-1,4-Dichloro-2-butene	ppb	-	-	-				
Dichlorodifluoromethane	ppb	-	-	-				
1,1-Dichloroethane	ppb	-	-	-				
1,2-Dichloroethane	ppb	-	-	-				
1,1-Dichloroethene	ppb	-	-	-				
trans-1,2-Dichloroethene	ppb	-	-	-				
1,2-Dichloropropane	ppb	-	-	-				
cis-1,3-Dichloropropene	ppb	-	-	-				
trans-1,3-Dichloropropene	ppb	-	-	-				
Ethanol	ppb	-	-	-				
Ethylbenzene	ppb	-	-	-				
Ethylene dibromide	ppb	-	-	-				
Ethyl methacrylate	ppb	-	-	-				
2-Hexanone	ppb	-	-	-				
Iodomethane	ppb	-	-	-				
4-Methyl-2-pentanone (MIBK)	ppb	-	-	-				
Methylene chloride	ppb	-	-	-				
Styrene	ppb	-	-	-				
Tetrachloroethylene	ppb	-	-	-				
1,1,2,2-Tetrachloroethane	ppb	-	-	-				
Toluene	ppb	-	-	-				
1,1,1-Trichloroethane	ppb	-	-	-				
1,1,2-Trichloroethane	ppb	-	-	-				
1,2,3-Trichloropropane	ppb	-	-	-				
Trichloroethene	ppb	-	-	-				
Trichlorofluoromethane	ppb	-	-	-				
Vinyl acetate	ppb	-	-	-				
Vinyl chloride	ppb	-	-	-				
Xylenes	ppb	-	-	-				

		River mouth		near Lease 97		near Lease 19 boundary					
		1-Jun-95	11-Oct-95	29-May-95	17-Oct-95	26-May-95	10-Oct-95				
Parameter	Units	data	data	data	data	data	data	min	median	max	count
Target PAHs and Alkylated PAHs											
Naphthalene	ppb	< 0.02	< 0.02	0.09	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.09	6
Methyl naphthalenes	ppb	< 0.02	0.03	0.08	< 0.02	< 0.04	< 0.02	< 0.04	< 0.02	0.08	6
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	0.06	0.08	< 0.04	< 0.04	< 0.04	< 0.04	0.08	6
C4 Subst'd naphthalenes	ppb	< 0.04	0.09	2.4	0.21	< 0.04	< 0.04	< 0.04	0.025	2.4	6
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	0.04	< 0.02	< 0.02	< 0.02	< 0.02	0.04	6
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	0.06	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.06	6
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Biphenyl	ppb	< 0.04	< 0.04	0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.04	6
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	0.42	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.42	6
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	0.91	0.06	< 0.04	< 0.04	< 0.04	< 0.04	0.91	6
C2 Substituted dibenzothiophen	ppb	< 0.04	0.13	3.7	0.16	< 0.04	< 0.04	< 0.04	0.045	3.7	6
C3 Subst'd dibenzothiophene	ppb	< 0.04	0.23	8.7	0.17	< 0.04	< 0.04	< 0.04	0.065	8.7	6
C4 Subst'd dibenzothiophene	ppb	< 0.04	0.06	7.1	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	7.1	6
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	0.46	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.46	6
Fluorene	ppb	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.03	6
Methyl fluorene	ppb	< 0.04	< 0.04	0.43	0.05	< 0.04	< 0.04	< 0.04	< 0.04	0.43	6
C2 Substituted fluorene	ppb	< 0.04	< 0.04	2.8	0.12	< 0.04	< 0.04	< 0.04	< 0.04	2.8	6
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl phenanthrene/anthracene	ppb	< 0.04	< 0.04	0.4	0.05	< 0.04	< 0.04	< 0.04	< 0.04	0.4	6
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	0.08	1.7	0.08	< 0.04	< 0.04	< 0.04	0.02	1.7	6
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	0.13	2.7	0.11	< 0.04	< 0.04	< 0.04	0.035	2.7	6
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	0.09	1.7	0.05	< 0.04	< 0.04	< 0.04	0.005	1.7	6
1-Methyl-7-isopropyl-phenanthr	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	6
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Target PANHs											
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	6
Phenolics											
Phenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	5
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	5
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	5
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	5
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	5
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	5
4-Nitrophenol	ppb	< 2	< 2	< 2	< 20	-	< 2	< 20	< 2	< 2	5
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 20	-	< 2	< 20	< 2	< 2	5
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 20	-	< 2	< 20	< 2	< 2	5
Volatile organics											
Acetone	ppb	250	-	41000	-	35000	-	250	35000	41000	3
Acrolein	ppb	< 100	-	< 100	-	< 100	-	< 100	< 100	< 100	3
Acrylonitrile	ppb	< 100	-	< 100	-	< 100	-	< 100	< 100	< 100	3
Benzene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Bromodichloromethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Bromoform	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Bromomethane	ppb	< 10	-	< 10	-	< 10	-	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	< 100	-	< 100	-	< 100	-	< 100	< 100	< 100	3

		River mouth		near Lease 97		near Lease 19 boundary					
		1-Jun-95	11-Oct-95	29-May-95	17-Oct-95	26-May-95	10-Oct-95				
Parameter	Units	data	data	data	data	data	data	min	median	max	count
Carbon disulfide	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Chlorobenzene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Chloroethane	ppb	< 10	-	< 10	-	< 10	-	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	< 5	-	< 5	-	< 5	-	< 5	< 5	< 5	3
Chloroform	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Chloromethane	ppb	< 10	-	< 10	-	< 10	-	< 10	< 10	< 10	3
Dibromochloromethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Dibromomethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	< 2	-	< 2	-	< 2	-	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	< 5	-	< 5	-	< 5	-	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Ethanol	ppb	< 100	-	< 100	-	< 100	-	< 100	< 100	< 100	3
Ethylbenzene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Ethylene dibromide	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	< 200	-	< 200	-	< 200	-	< 200	< 200	< 200	3
2-Hexanone	ppb	< 200	-	< 200	-	< 200	-	< 200	< 200	< 200	3
Iodomethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	< 200	-	< 200	-	< 200	< 200	< 200	3
Methylene chloride	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Styrene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	< 5	-	< 5	-	< 5	-	< 5	< 5	< 5	3
Toluene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	< 2	-	< 2	-	< 2	-	< 2	< 2	< 2	3
Trichloroethene	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3
Vinyl acetate	ppb	< 100	-	< 100	-	< 100	-	< 100	< 100	< 100	3
Vinyl chloride	ppb	< 20	-	< 20	-	< 20	-	< 20	< 20	< 20	3
Xylenes	ppb	< 1	-	< 1	-	< 1	-	< 1	< 1	< 1	3

		Mouth of the Muskeg River	Jackpine Creek
		Fall 1995	Fall 1995
Parameter	Units	data	data
Target PAHs and Alkylated PAHs		-	-
Naphthalene	ppb	< 0.02	< 0.02
Methyl naphthalenes	ppb	< 0.02	< 0.02
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04
Acenaphthene	ppb	< 0.02	< 0.02
Methyl acenaphthene	ppb	< 0.04	< 0.04
Acenaphthylene	ppb	< 0.02	< 0.02
Anthracene	ppb	< 0.02	< 0.02
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04
Benzo(a)pyrene	ppb	< 0.02	< 0.02
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02
Biphenyl	ppb	< 0.04	< 0.04
Methyl biphenyl	ppb	< 0.04	< 0.04
C2 Substituted biphenyl	ppb	< 0.04	< 0.04
Dibenzothiophene	ppb	< 0.02	< 0.02
Methyl dibenzothiophene	ppb	< 0.04	< 0.04
C2 Substituted dibenzothiophen	ppb	< 0.04	< 0.04
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04
Fluoranthene	ppb	< 0.02	< 0.02
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04
Fluorene	ppb	< 0.02	< 0.02
Methyl fluorene	ppb	< 0.04	< 0.04
C2 Substituted fluorene	ppb	< 0.04	< 0.04
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02
Phenanthrene	ppb	< 0.02	< 0.02
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04
1-Methyl-7-isopropyl-phenanth	ppb	< 0.04	< 0.04
Pyrene	ppb	< 0.02	< 0.02
Target PANHs		-	-
quinoline	ppb	< 0.02	< 0.02
7-Methyl quinoline	ppb	< 0.02	< 0.02
C2 Subst'd quinoline	ppb	< 0.02	< 0.02
C3 Subst'd quinoline	ppb	< 0.02	< 0.02
Acridine	ppb	< 0.02	< 0.02
Methyl acridine	ppb	< 0.02	< 0.02
Phenanthridine	ppb	< 0.02	< 0.02
Carbazole	ppb	< 0.02	< 0.02
Methyl carbazole	ppb	< 0.02	< 0.02
C2 Subst'd carbazole	ppb	< 0.02	< 0.02
Phenolics		-	-
Phenol	ppb	< 0.1	< 0.1
o-Cresol	ppb	< 0.1	< 0.1
m-Cresol	ppb	< 0.1	< 0.1
p-Cresol	ppb	< 0.1	< 0.1
2,4-Dimethylphenol	ppb	< 0.1	< 0.1
2-Nitrophenol	ppb	< 0.2	< 0.2

		Mouth of the Muskeg River	Jackpine Creek
		Fall 1995	Fall 1995
Parameter	Units	data	data
4-Nitrophenol	ppb	< 2	< 2
2,4-Dinitrophenol	ppb	< 2	< 2
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2
Volatile organics		-	-
Acetone	ppb	-	-
Acrolein	ppb	-	-
Acrylonitrile	ppb	-	-
Benzene	ppb	-	-
Bromodichloromethane	ppb	-	-
Bromoform	ppb	-	-
Bromomethane	ppb	-	-
2-Butanone (MEK)	ppb	-	-
Carbon disulfide	ppb	-	-
Carbon tetrachloride	ppb	-	-
Chlorobenzene	ppb	-	-
Chloroethane	ppb	-	-
2-Chloroethyl vinyl ether	ppb	-	-
Chloroform	ppb	-	-
Chloromethane	ppb	-	-
Dibromochloromethane	ppb	-	-
Dibromomethane	ppb	-	-
1,2-Dichlorobenzene	ppb	-	-
1,3-Dichlorobenzene	ppb	-	-
1,4-Dichlorobenzene	ppb	-	-
cis-1,4-Dichloro-2-butene	ppb	-	-
trans-1,4-Dichloro-2-butene	ppb	-	-
Dichlorodifluoromethane	ppb	-	-
1,1-Dichloroethane	ppb	-	-
1,2-Dichloroethane	ppb	-	-
1,1-Dichloroethene	ppb	-	-
trans-1,2-Dichloroethene	ppb	-	-
1,2-Dichloropropane	ppb	-	-
cis-1,3-Dichloropropene	ppb	-	-
trans-1,3-Dichloropropene	ppb	-	-
Ethanol	ppb	-	-
Ethylbenzene	ppb	-	-
Ethylene dibromide	ppb	-	-
Ethyl methacrylate	ppb	-	-
2-Hexanone	ppb	-	-
Iodomethane	ppb	-	-
4-Methyl-2-pentanone (MIBK)	ppb	-	-
Methylene chloride	ppb	-	-
Styrene	ppb	-	-
Tetrachloroethylene	ppb	-	-
1,1,2,2-Tetrachloroethane	ppb	-	-
Toluene	ppb	-	-
1,1,1-Trichloroethane	ppb	-	-
1,1,2-Trichloroethane	ppb	-	-
1,2,3-Trichloropropane	ppb	-	-
Trichloroethene	ppb	-	-
Trichlorofluoromethane	ppb	-	-
Vinyl acetate	ppb	-	-
Vinyl chloride	ppb	-	-
Xylenes	ppb	-	-

		RAMP 1997	Samples collected by Golder near Tar Island Dyke in 1995			RAMP 1997	
		at Donald Creek	et. bk., top of TID	wt. bk., start of TID	wt. bk., by Ship. Lk.	Duplicates at Fort Creek	
		6-Oct-97	fall	fall	fall	10-Oct-97	10-Oct-97
Parameter	Units	data	data	data	data	data	data
Target PAHs and Alkylated PAHs							
Naphthalene	ug/g	<0.01	< 0.01	0.01	0.02	0.005	0.006
Methyl naphthalenes	ug/g	<0.02	< 0.01	0.01	0.02	0.015	0.015
C2 Subst'd naphthalenes	ug/g	0.02	< 0.02	< 0.02	0.02	0.03	0.04
C3 Subst'd naphthalenes	ug/g	0.03	< 0.02	< 0.02	< 0.02	0.06	0.05
C4 Subst'd naphthalenes	ug/g	<0.02	< 0.02	< 0.02	< 0.02	0.06	0.05
Acenaphthene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	<0.003	<0.003
Methyl acenaphthene	ug/g	<0.02	< 0.02	< 0.02	< 0.02	<0.02	<0.02
Acenaphthylene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	<0.003	<0.003
Anthracene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	<0.003	<0.003
Dibenzo(a,h)anthracene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	<0.003	<0.003
Benzo(a)Anthracene/Chrys	ug/g	0.02	< 0.01	0.01	0.03	0.027	0.023
Methyl benzo(a)anthracene	ug/g	0.03	< 0.02	< 0.02	0.03	0.03	0.04
C2 Subst'd benzo(a)anthra	ug/g	0.05	< 0.02	< 0.02	0.04	0.09	0.08
Benzo(a)pyrene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	0.006	0.006
Methyl benzo(b&k) fluorar	ug/g	0.03	< 0.02	< 0.02	0.05	0.03	0.04
C2 Subst'd benzo(b& k) fl	ug/g	0.03	< 0.02	< 0.02	0.04	0.03	0.04
Benzo(b&k)fluoranthene	ug/g	0.01	0.01	0.02	< 0.01	0.018	0.018
Benzo(g,h,i)perylene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	0.007	0.006
Biphenyl	ug/g	<0.02	< 0.02	< 0.02	< 0.02	<0.02	<0.02
Methyl biphenyl	ug/g	<0.02	< 0.02	< 0.02	< 0.02	<0.02	<0.02
C2 Substituted biphenyl	ug/g	<0.02	< 0.02	< 0.02	< 0.02	<0.02	<0.02
Dibenzothiophene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	<0.003	0.19
Methyl dibenzothiophene	ug/g	<0.02	< 0.02	< 0.02	< 0.02	0.03	0.02
C2 Substituted dibenzothio	ug/g	0.02	< 0.02	< 0.02	0.03	0.10	0.09
C3 Subst'd dibenzothiophe	ug/g	0.04	< 0.02	< 0.02	0.06	0.20	0.20
C4 Subst'd dibenzothiophe	ug/g	0.05	< 0.02	< 0.02	< 0.02	<0.02	<0.02
Fluoranthene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	0.006	0.005
Methyl fluoranthene/pyren	ug/g	0.03	< 0.02	< 0.02	0.05	0.05	0.04
Fluorene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	<0.003	0.004
Methyl fluorene	ug/g	<0.02	< 0.02	< 0.02	< 0.02	<0.02	<0.02
C2 Substituted fluorene	ug/g	<0.02	< 0.02	< 0.02	< 0.02	0.04	0.05
Indeno(c,d-123)pyrene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	0.006	0.005
Phenanthrene	ug/g	0.01	< 0.01	< 0.01	0.01	0.012	0.012
Methyl phenanthrene/anthr	ug/g	<0.02	< 0.02	0.02	0.05	0.03	0.02
C2 Subst'd phenanthrene/a	ug/g	0.03	< 0.02	< 0.02	0.04	0.12	0.12
C3 Subst'd phenanthrene/a	ug/g	0.04	0.03	0.03	0.07	0.14	0.13
C4 Subst'd phenanthrene/a	ug/g	0.04	0.03	0.03	0.09	0.05	0.09
1-Methyl-7-isopropyl-phen	ug/g	-	< 0.02	< 0.02	< 0.02	-	-
Pyrene	ug/g	<0.01	< 0.01	< 0.01	< 0.01	0.011	0.008
Target PANHs							
quinoline	ug/g	-	< 0.01	< 0.01	0.01		
7-Methyl quinoline	ug/g	-	< 0.01	< 0.01	< 0.01		
C2 Subst'd quinoline	ug/g	-	< 0.01	< 0.01	< 0.01		
C3 Subst'd quinoline	ug/g	-	< 0.01	< 0.01	< 0.01		
Acridine	ug/g	-	< 0.01	< 0.01	< 0.01		
Methyl acridine	ug/g	-	< 0.01	< 0.01	< 0.01		
Phenanthridine	ug/g	-	< 0.01	< 0.01	< 0.01		
Carbazole	ug/g	-	< 0.01	< 0.01	< 0.01		
Methyl carbazole	ug/g	-	< 0.01	< 0.01	< 0.01		
C2 Subst'd carbazole	ug/g	-	< 0.01	< 0.01	< 0.01		
Phenolics							
Phenol	ug/g	-	-	-	-	-	-
o-Cresol	ug/g	-	-	-	-	-	-
m-Cresol	ug/g	-	-	-	-	-	-
p-Cresol	ug/g	-	-	-	-	-	-
2,4-Dimethylphenol	ug/g	-	-	-	-	-	-
2-Nitrophenol	ug/g	-	-	-	-	-	-
4-Nitrophenol	ug/g	-	-	-	-	-	-
2,4-Dinitrophenol	ug/g	-	-	-	-	-	-
4,6-Dinitro-2-methyl phenc	ug/g	-	-	-	-	-	-
Volatile organics							
Acetone	ug/g	-	-	-	-	-	-
Acrolein	ug/g	-	-	-	-	-	-
Acrylonitrile	ug/g	-	-	-	-	-	-
Benzene	ug/g	-	-	-	-	-	-
Bromodichloromethane	ug/g	-	-	-	-	-	-

		RAMP 1997	Samples collected by Golder near Tar Island Dyke in 1995			RAMP 1997	
		at Donald Creek	et. bk., top of TID	wt. bk., start of TID	wt. bk., by Ship. Lk.	Duplicates at Fort Creek	
		6-Oct-97	fall	fall	fall	10-Oct-97	10-Oct-97
Parameter	Units	data	data	data	data	data	data
Bromoform	ug/g	-	-	-	-	-	-
Bromomethane	ug/g	-	-	-	-	-	-
2-Butanone (MEK)	ug/g	-	-	-	-	-	-
Carbon disulfide	ug/g	-	-	-	-	-	-
Carbon tetrachloride	ug/g	-	-	-	-	-	-
Chlorobenzene	ug/g	-	-	-	-	-	-
Chloroethane	ug/g	-	-	-	-	-	-
2-Chloroethyl vinyl ether	ug/g	-	-	-	-	-	-
Chloroform	ug/g	-	-	-	-	-	-
Chloromethane	ug/g	-	-	-	-	-	-
Dibromochloromethane	ug/g	-	-	-	-	-	-
Dibromomethane	ug/g	-	-	-	-	-	-
1,2-Dichlorobenzene	ug/g	-	-	-	-	-	-
1,3-Dichlorobenzene	ug/g	-	-	-	-	-	-
1,4-Dichlorobenzene	ug/g	-	-	-	-	-	-
cis-1,4-Dichloro-2-butene	ug/g	-	-	-	-	-	-
trans-1,4-Dichloro-2-buten	ug/g	-	-	-	-	-	-
Dichlorodifluoromethane	ug/g	-	-	-	-	-	-
1,1-Dichloroethane	ug/g	-	-	-	-	-	-
1,2-Dichloroethane	ug/g	-	-	-	-	-	-
1,1-Dichloroethene	ug/g	-	-	-	-	-	-
trans-1,2-Dichloroethene	ug/g	-	-	-	-	-	-
1,2-Dichloropropane	ug/g	-	-	-	-	-	-
cis-1,3-Dichloropropene	ug/g	-	-	-	-	-	-
trans-1,3-Dichloropropene	ug/g	-	-	-	-	-	-
Ethanol	ug/g	-	-	-	-	-	-
Ethylbenzene	ug/g	-	-	-	-	-	-
Ethylene dibromide	ug/g	-	-	-	-	-	-
Ethyl methacrylate	ug/g	-	-	-	-	-	-
2-Hexanone	ug/g	-	-	-	-	-	-
Iodomethane	ug/g	-	-	-	-	-	-
4-Methyl-2-pentanone (MI	ug/g	-	-	-	-	-	-
Methylene chloride	ug/g	-	-	-	-	-	-
Styrene	ug/g	-	-	-	-	-	-
Tetrachloroethylene	ug/g	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	ug/g	-	-	-	-	-	-
Toluene	ug/g	-	-	-	-	-	-
1,1,1-Trichloroethane	ug/g	-	-	-	-	-	-
1,1,2-Trichloroethane	ug/g	-	-	-	-	-	-
1,2,3-Trichloropropane	ug/g	-	-	-	-	-	-
Trichloroethene	ug/g	-	-	-	-	-	-
Trichlorofluoromethane	ug/g	-	-	-	-	-	-
Vinyl acetate	ug/g	-	-	-	-	-	-
Vinyl chloride	ug/g	-	-	-	-	-	-
Xylenes	ug/g	-	-	-	-	-	-

		RAMP 1997	Samples collected by Golder in 1995					
		- at mouth	- at the river mouth				- at Lease 19 boundary	
		11-Oct-97	Spring	Spring	Fall	Fall	Spring	Fall
Parameter	Units	data	data	data	data	data	data	data
Target PAHs and Alkylated PAHs								
Naphthalene	ug/g	<0.003	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Methyl naphthalenes	ug/g	<0.003	< 0.02	< 0.02	< 0.01	0.01	< 0.01	< 0.02
C2 Subst'd naphthalenes	ug/g	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C3 Subst'd naphthalenes	ug/g	0.19	0.03	< 0.02	0.43	0.19	< 0.02	< 0.02
C4 Subst'd naphthalenes	ug/g	0.66	0.1	0.07	1.7	0.84	< 0.02	< 0.02
Acenaphthene	ug/g	0.012	< 0.01	< 0.01	0.05	0.02	< 0.01	< 0.01
Methyl acenaphthene	ug/g	0.04	< 0.02	< 0.02	0.19	0.09	< 0.02	< 0.02
Acenaphthylene	ug/g	0.008	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Anthracene	ug/g	0.004	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dibenzo(a,h)anthracene	ug/g	<0.003	< 0.01	< 0.01	0.13	0.06	< 0.01	< 0.01
Benzo(a)Anthracene/Chrys	ug/g	0.17	< 0.01	< 0.01	2.8	0.99	< 0.01	< 0.01
Methyl benzo(a)anthracene	ug/g	0.38	< 0.02	< 0.02	3.6	1.8	< 0.02	< 0.02
C2 Subst'd benzo(a)anthra(	ug/g	0.68	< 0.02	< 0.02	4.4	2.2	< 0.02	< 0.02
Benzo(a)pyrene	ug/g	0.097	< 0.01	< 0.01	0.29	0.12	< 0.01	< 0.01
Methyl benzo(b&k) fluorar	ug/g	0.24	< 0.02	< 0.02	1.8	0.83	< 0.02	< 0.02
C2 Subst'd benzo(b& k) flu	ug/g	0.26	< 0.02	< 0.02	0.79	0.47	< 0.02	< 0.02
Benzo(b&k)fluoranthene	ug/g	0.076	< 0.01	< 0.01	0.62	0.31	< 0.01	< 0.01
Benzo(g,h,i)perylene	ug/g	0.017	< 0.01	< 0.01	0.27	0.14	< 0.01	< 0.01
Biphenyl	ug/g	<0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl biphenyl	ug/g	<0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02
C2 Substituted biphenyl	ug/g	0.09	< 0.02	< 0.02	0.17	0.08	< 0.02	< 0.02
Dibenzothiophene	ug/g	0.020	< 0.01	< 0.01	0.05	0.02	< 0.01	< 0.01
Methyl dibenzothiophene	ug/g	0.19	0.09	0.06	1.5	0.79	< 0.02	< 0.02
C2 Substituted dibenzothio	ug/g	1.2	0.27	0.18	6.5	3.7	< 0.02	< 0.02
C3 Subst'd dibenzothiophe	ug/g	2.0	0.42	0.16	6.6	3.4	< 0.02	< 0.02
C4 Subst'd dibenzothiophe	ug/g	2.5	0.13	0.05	8.1	4.7	< 0.02	< 0.02
Fluoranthene	ug/g	0.023	< 0.01	< 0.01	0.16	0.08	< 0.01	< 0.01
Methyl fluoranthene/pyren(	ug/g	0.35	< 0.02	< 0.02	1.4	0.73	< 0.02	< 0.02
Fluorene	ug/g	0.005	< 0.01	< 0.01	0.03	0.02	< 0.01	< 0.01
Methyl fluorene	ug/g	0.04	0.05	< 0.02	0.44	0.18	< 0.02	< 0.02
C2 Substituted fluorene	ug/g	0.33	0.11	0.08	2.2	0.95	< 0.02	< 0.02
Indeno(c,d-123)pyrene	ug/g	0.008	< 0.01	< 0.01	0.2	0.09	< 0.01	< 0.01
Phenanthrene	ug/g	0.020	0.02	< 0.01	0.42	0.19	< 0.01	< 0.01
Methyl phenanthrene/anthr	ug/g	0.15	0.08	0.02	3.5	1.6	< 0.02	< 0.02
C2 Subst'd phenanthrene/a	ug/g	1.4	0.16	0.04	9.9	4.9	< 0.02	< 0.02
C3 Subst'd phenanthrene/a	ug/g	1.8	0.16	0.05	11	5.8	< 0.02	< 0.02
C4 Subst'd phenanthrene/a	ug/g	1.3	0.03	0.02	7.3	2.3	< 0.02	< 0.02
1-Methyl-7-isopropyl-phen	ug/g	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Pyrene	ug/g	0.072	< 0.01	< 0.01	0.25	0.14	< 0.01	< 0.01
Target PANHs								
quinoline	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
7-Methyl quinoline	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
C2 Subst'd quinoline	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
C3 Subst'd quinoline	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Acridine	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Methyl acridine	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenanthridine	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Carbazole	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Methyl carbazole	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
C2 Subst'd carbazole	ug/g	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phenolics								
Phenol	ug/g	-	-	-	-	-	-	-
o-Cresol	ug/g	-	-	-	-	-	-	-
m-Cresol	ug/g	-	-	-	-	-	-	-
p-Cresol	ug/g	-	-	-	-	-	-	-
2,4-Dimethylphenol	ug/g	-	-	-	-	-	-	-
2-Nitrophenol	ug/g	-	-	-	-	-	-	-
4-Nitrophenol	ug/g	-	-	-	-	-	-	-

		RAMP 1997	Samples collected by Golder in 1995					
		- at mouth	- at the river mouth				- at Lease 19 boundary	
		11-Oct-97	Spring	Spring	Fall	Fall	Spring	Fall
Parameter	Units	data	data	data	data	data	data	data
2,4-Dinitrophenol	ug/g	-	-	-	-	-	-	-
4,6-Dinitro-2-methyl phenc	ug/g	-	-	-	-	-	-	-
Volatile organics								
Acetone	ug/g	-	-	-	-	-	-	-
Acrolein	ug/g	-	-	-	-	-	-	-
Acrylonitrile	ug/g	-	-	-	-	-	-	-
Benzene	ug/g	-	-	-	-	-	-	-
Bromodichloromethane	ug/g	-	-	-	-	-	-	-
Bromoform	ug/g	-	-	-	-	-	-	-
Bromomethane	ug/g	-	-	-	-	-	-	-
2-Butanone (MEK)	ug/g	-	-	-	-	-	-	-
Carbon disulfide	ug/g	-	-	-	-	-	-	-
Carbon tetrachloride	ug/g	-	-	-	-	-	-	-
Chlorobenzene	ug/g	-	-	-	-	-	-	-
Chloroethane	ug/g	-	-	-	-	-	-	-
2-Chloroethyl vinyl ether	ug/g	-	-	-	-	-	-	-
Chloroform	ug/g	-	-	-	-	-	-	-
Chloromethane	ug/g	-	-	-	-	-	-	-
Dibromochloromethane	ug/g	-	-	-	-	-	-	-
Dibromomethane	ug/g	-	-	-	-	-	-	-
1,2-Dichlorobenzene	ug/g	-	-	-	-	-	-	-
1,3-Dichlorobenzene	ug/g	-	-	-	-	-	-	-
1,4-Dichlorobenzene	ug/g	-	-	-	-	-	-	-
cis-1,4-Dichloro-2-butene	ug/g	-	-	-	-	-	-	-
trans-1,4-Dichloro-2-buten	ug/g	-	-	-	-	-	-	-
Dichlorodifluoromethane	ug/g	-	-	-	-	-	-	-
1,1-Dichloroethane	ug/g	-	-	-	-	-	-	-
1,2-Dichloroethane	ug/g	-	-	-	-	-	-	-
1,1-Dichloroethene	ug/g	-	-	-	-	-	-	-
trans-1,2-Dichloroethene	ug/g	-	-	-	-	-	-	-
1,2-Dichloropropane	ug/g	-	-	-	-	-	-	-
cis-1,3-Dichloropropene	ug/g	-	-	-	-	-	-	-
trans-1,3-Dichloropropene	ug/g	-	-	-	-	-	-	-
Ethanol	ug/g	-	-	-	-	-	-	-
Ethylbenzene	ug/g	-	-	-	-	-	-	-
Ethylene dibromide	ug/g	-	-	-	-	-	-	-
Ethyl methacrylate	ug/g	-	-	-	-	-	-	-
2-Hexanone	ug/g	-	-	-	-	-	-	-
Iodomethane	ug/g	-	-	-	-	-	-	-
4-Methyl-2-pentanone (MI	ug/g	-	-	-	-	-	-	-
Methylene chloride	ug/g	-	-	-	-	-	-	-
Styrene	ug/g	-	-	-	-	-	-	-
Tetrachloroethylene	ug/g	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	ug/g	-	-	-	-	-	-	-
Toluene	ug/g	-	-	-	-	-	-	-
1,1,1-Trichloroethane	ug/g	-	-	-	-	-	-	-
1,1,2-Trichloroethane	ug/g	-	-	-	-	-	-	-
1,2,3-Trichloropropane	ug/g	-	-	-	-	-	-	-
Trichloroethene	ug/g	-	-	-	-	-	-	-
Trichlorofluoromethane	ug/g	-	-	-	-	-	-	-
Vinyl acetate	ug/g	-	-	-	-	-	-	-
Vinyl chloride	ug/g	-	-	-	-	-	-	-
Xylenes	ug/g	-	-	-	-	-	-	-

Parameter	Units	Mouth of Muskeg River 17-Oct-98 data	Muskeg River upstream Jackpine Creek 17-Oct-98 data	Mouth of MacKay River 11-Oct-97 data	Mouth of Jackpine Creek 17-Oct-97 data	Mouth of Poplar Creek 11-Oct-97 data
Target PAHs and Alkylated PAHs						
Naphthalene	ug/g	<0.003	0.003	0.008	<0.003	0.006
Methyl naphthalenes	ug/g	<0.003	<0.003	0.006	<0.003	0.019
C2 Subst'd naphthalenes	ug/g	<0.02	0.03	0.06	0.02	0.05
C3 Subst'd naphthalenes	ug/g	0.04	0.03	0.42	0.04	0.05
C4 Subst'd naphthalenes	ug/g	0.06	0.16	0.75	0.09	0.05
Acenaphthene	ug/g	<0.003	<0.003	0.016	<0.003	<0.003
Methyl acenaphthene	ug/g	<0.02	<0.02	0.04	<0.02	<0.02
Acenaphthylene	ug/g	<0.003	0.004	0.004	<0.003	<0.003
Anthracene	ug/g	<0.003	<0.003	<0.003	<0.003	<0.003
Dibenzo(a,h)anthracene	ug/g	<0.003	<0.003	<0.003	<0.003	<0.003
Benzo(a)Anthracene/Chrys	ug/g	0.035	0.057	0.11	0.034	0.025
Methyl benzo(a)anthracene	ug/g	0.07	0.12	0.25	0.05	0.05
C2 Subst'd benzo(a)anthra	ug/g	0.13	0.20	0.40	0.09	0.09
Benzo(a)pyrene	ug/g	0.013	0.016	0.023	0.015	0.007
Methyl benzo(b&k) fluorar	ug/g	0.09	0.12	0.15	0.12	0.02
C2 Subst'd benzo(b& k) flu	ug/g	0.10	0.19	0.11	0.10	0.06
Benzo(b&k)fluoranthene	ug/g	0.014	0.034	0.053	0.023	0.023
Benzo(g,h,i)perylene	ug/g	0.012	0.010	0.017	0.010	0.012
Biphenyl	ug/g	<0.02	<0.02	<0.02	<0.02	<0.02
Methyl biphenyl	ug/g	<0.02	<0.02	<0.02	<0.02	<0.02
C2 Substituted biphenyl	ug/g	<0.02	<0.02	<0.02	<0.02	0.02
Dibenzothiophene	ug/g	<0.003	0.005	0.022	0.005	0.006
Methyl dibenzothiophene	ug/g	<0.02	0.03	0.31	0.03	0.03
C2 Substituted dibenzothio	ug/g	0.11	0.30	1.2	0.15	0.11
C3 Subst'd dibenzothiophe	ug/g	0.21	0.58	1.4	0.25	0.20
C4 Subst'd dibenzothiophe	ug/g	0.24	0.56	1.8	0.28	0.29
Fluoranthene	ug/g	0.003	0.006	0.022	0.004	0.005
Methyl fluoranthene/pyren	ug/g	0.07	0.07	0.25	0.03	0.05
Fluorene	ug/g	<0.003	<0.003	0.011	<0.003	<0.003
Methyl fluorene	ug/g	<0.02	0.02	0.08	0.02	<0.02
C2 Substituted fluorene	ug/g	0.06	0.15	0.43	0.08	0.06
Indeno(c,d-123)pyrene	ug/g	0.006	0.009	0.010	<0.003	0.010
Phenanthrene	ug/g	0.007	0.009	0.080	<0.003	0.015
Methyl phenanthrene/anthr	ug/g	0.04	0.09	0.28	0.08	0.02
C2 Subst'd phenanthrene/a	ug/g	0.10	0.26	1.3	0.19	0.13
C3 Subst'd phenanthrene/a	ug/g	0.18	0.60	1.2	0.21	0.16
C4 Subst'd phenanthrene/a	ug/g	0.11	0.21	0.82	0.10	0.08
1-Methyl-7-isopropyl-phen	ug/g	-	-	-	-	-
Pyrene	ug/g	0.012	0.015	0.047	0.006	0.010
Target PANHs						
quinoline	ug/g	-	-	-	-	-
7-Methyl quinoline	ug/g	-	-	-	-	-
C2 Subst'd quinoline	ug/g	-	-	-	-	-
C3 Subst'd quinoline	ug/g	-	-	-	-	-
Acridine	ug/g	-	-	-	-	-
Methyl acridine	ug/g	-	-	-	-	-
Phenanthridine	ug/g	-	-	-	-	-
Carbazole	ug/g	-	-	-	-	-
Methyl carbazole	ug/g	-	-	-	-	-
C2 Subst'd carbazole	ug/g	-	-	-	-	-
Phenolics						
Phenol	ug/g	-	-	-	-	-
o-Cresol	ug/g	-	-	-	-	-
m-Cresol	ug/g	-	-	-	-	-
p-Cresol	ug/g	-	-	-	-	-
2,4-Dimethylphenol	ug/g	-	-	-	-	-
2-Nitrophenol	ug/g	-	-	-	-	-
4-Nitrophenol	ug/g	-	-	-	-	-
2,4-Dinitrophenol	ug/g	-	-	-	-	-

		Mouth of Muskeg River	Muskeg River upstream Jackpine Creek	Mouth of MacKay River	Mouth of Jackpine Creek	Mouth of Poplar Creek
		17-Oct-98	17-Oct-98	11-Oct-97	17-Oct-97	11-Oct-97
Parameter	**Units**	**data**	**data**	**data**	**data**	**data**
4,6-Dinitro-2-methyl phenc	ug/g	-	-	-	-	-
Volatile organics						
Acetone	ug/g	-	-	-	-	-
Acrolein	ug/g	-	-	-	-	-
Acrylonitrile	ug/g	-	-	-	-	-
Benzene	ug/g	-	-	-	-	-
Bromodichloromethane	ug/g	-	-	-	-	-
Bromoform	ug/g	-	-	-	-	-
Bromomethane	ug/g	-	-	-	-	-
2-Butanone (MEK)	ug/g	-	-	-	-	-
Carbon disulfide	ug/g	-	-	-	-	-
Carbon tetrachloride	ug/g	-	-	-	-	-
Chlorobenzene	ug/g	-	-	-	-	-
Chloroethane	ug/g	-	-	-	-	-
2-Chloroethyl vinyl ether	ug/g	-	-	-	-	-
Chloroform	ug/g	-	-	-	-	-
Chloromethane	ug/g	-	-	-	-	-
Dibromochloromethane	ug/g	-	-	-	-	-
Dibromomethane	ug/g	-	-	-	-	-
1,2-Dichlorobenzene	ug/g	-	-	-	-	-
1,3-Dichlorobenzene	ug/g	-	-	-	-	-
1,4-Dichlorobenzene	ug/g	-	-	-	-	-
cis-1,4-Dichloro-2-butene	ug/g	-	-	-	-	-
trans-1,4-Dichloro-2-buten	ug/g	-	-	-	-	-
Dichlorodifluoromethane	ug/g	-	-	-	-	-
1,1-Dichloroethane	ug/g	-	-	-	-	-
1,2-Dichloroethane	ug/g	-	-	-	-	-
1,1-Dichloroethene	ug/g	-	-	-	-	-
trans-1,2-Dichloroethene	ug/g	-	-	-	-	-
1,2-Dichloropropane	ug/g	-	-	-	-	-
cis-1,3-Dichloropropene	ug/g	-	-	-	-	-
trans-1,3-Dichloropropene	ug/g	-	-	-	-	-
Ethanol	ug/g	-	-	-	-	-
Ethylbenzene	ug/g	-	-	-	-	-
Ethylene dibromide	ug/g	-	-	-	-	-
Ethyl methacrylate	ug/g	-	-	-	-	-
2-Hexanone	ug/g	-	-	-	-	-
Iodomethane	ug/g	-	-	-	-	-
4-Methyl-2-pentanone (MI	ug/g	-	-	-	-	-
Methylene chloride	ug/g	-	-	-	-	-
Styrene	ug/g	-	-	-	-	-
Tetrachloroethylene	ug/g	-	-	-	-	-
1,1,2,2-Tetrachloroethane	ug/g	-	-	-	-	-
Toluene	ug/g	-	-	-	-	-
1,1,1-Trichloroethane	ug/g	-	-	-	-	-
1,1,2-Trichloroethane	ug/g	-	-	-	-	-
1,2,3-Trichloropropane	ug/g	-	-	-	-	-
Trichloroethene	ug/g	-	-	-	-	-
Trichlorofluoromethane	ug/g	-	-	-	-	-
Vinyl acetate	ug/g	-	-	-	-	-
Vinyl chloride	ug/g	-	-	-	-	-
Xylenes	ug/g	-	-	-	-	-

		Sampling for Suncor 1995 study (site AW004)						
		31-May-95	14-Aug-95	2-Oct-95				
Parameter	**Units**	**data**	**data**	**data**	**min**	**median**	**max**	**count**
Target PAHs and Alkylated PAHs		-	-	-				
Naphthalene	ppb	< 0.4	< 0.02	< 0.02	< 0.4	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.1	< 0.02	< 0.02	< 0.1	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		0	0	0	0	0	0	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		0	0	0	0	0	0	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted dibenzothiophen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanth	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Total PAHs		0	0	0	0	0	0	3
Target PANHs		-	-	-				
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenolics		-	-	-				
Phenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3
4-Nitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3

		Sampling for Suncor 1995 study (site AW004)						
		31-May-95	14-Aug-95	2-Oct-95				
Parameter	Units	data	data	data	min	median	max	count
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
Volatile organics		-	-	-				
Acetone	ppb	< 100	-	-		< 100		1
Acrolein	ppb	< 100	-	-		< 100		1
Acrylonitrile	ppb	< 100	-	-		< 100		1
Benzene	ppb	< 1	-	-		< 1		1
Bromodichloromethane	ppb	< 1	-	-		< 1		1
Bromoform	ppb	< 1	-	-		< 1		1
Bromomethane	ppb	< 10	-	-		< 10		1
2-Butanone (MEK)	ppb	< 100	-	-		< 100		1
Carbon disulfide	ppb	< 1	-	-		< 1		1
Carbon tetrachloride	ppb	< 1	-	-		< 1		1
Chlorobenzene	ppb	< 1	-	-		< 1		1
Chloroethane	ppb	< 10	-	-		< 10		1
2-Chloroethyl vinyl ether	ppb	< 5	-	-		< 5		1
Chloroform	ppb	< 1	-	-		< 1		1
Chloromethane	ppb	< 10	-	-		< 10		1
Dibromochloromethane	ppb	< 1	-	-		< 1		1
Dibromomethane	ppb	< 1	-	-		< 1		1
1,2-Dichlorobenzene	ppb	< 1	-	-		< 1		1
1,3-Dichlorobenzene	ppb	< 1	-	-		< 1		1
1,4-Dichlorobenzene	ppb	< 1	-	-		< 1		1
cis-1,4-Dichloro-2-butene	ppb	< 2	-	-		< 2		1
trans-1,4-Dichloro-2-butene	ppb	< 5	-	-		< 5		1
Dichlorodifluoromethane	ppb	< 1	-	-		< 1		1
1,1-Dichloroethane	ppb	< 1	-	-		< 1		1
1,2-Dichloroethane	ppb	< 1	-	-		< 1		1
1,1-Dichloroethene	ppb	< 1	-	-		< 1		1
trans-1,2-Dichloroethene	ppb	< 1	-	-		< 1		1
1,2-Dichloropropane	ppb	< 1	-	-		< 1		1
cis-1,3-Dichloropropene	ppb	< 1	-	-		< 1		1
trans-1,3-Dichloropropene	ppb	< 1	-	-		< 1		1
Ethanol	ppb	< 100	-	-		< 100		1
Ethylbenzene	ppb	< 1	-	-		< 1		1
Ethylene dibromide	ppb	< 1	-	-		< 1		1
Ethyl methacrylate	ppb	< 200	-	-		< 200		1
2-Hexanone	ppb	< 200	-	-		< 200		1
Iodomethane	ppb	< 1	-	-		< 1		1
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	-		< 200		1
Methylene chloride	ppb	< 1	-	-		< 1		1
Styrene	ppb	< 1	-	-		< 1		1
Tetrachloroethylene	ppb	< 1	-	-		< 1		1
1,1,2,2-Tetrachloroethane	ppb	< 5	-	-		< 5		1
Toluene	ppb	< 1	-	-		< 1		1
1,1,1-Trichloroethane	ppb	< 1	-	-		< 1		1
1,1,2-Trichloroethane	ppb	< 1	-	-		< 1		1
1,2,3-Trichloropropane	ppb	< 2	-	-		< 2		1
Trichloroethene	ppb	< 1	-	-		< 1		1
Trichlorofluoromethane	ppb	< 1	-	-		< 1		1
Vinyl acetate	ppb	< 100	-	-		< 100		1
Vinyl chloride	ppb	< 20	-	-		< 20		1
Xylenes	ppb	< 1	-	-		< 1		1

WATER QUALITY FOR THE ATHABASCA RIVER ADJACENT TO SALINE LAKE

Attachment 1

		Sampling for Suncor 1995 study (site AW009)					
		13-May-95	14-Aug-95				
Parameter	**Units**	**data**	**data**	**min**	**median**	**max**	**count**
Target PAHs and Alkylated PAHs		-	-				
Naphthalene	ppb	0.03	< 0.02	< 0.02		0.03	2
Methyl naphthalenes	ppb	0.02	< 0.02	< 0.02		0.02	2
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Anthracene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Benzo(a)anthracene grp		0	0	0		0	2
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Benzo(a)pyrene grp		0	0	0		0	2
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Biphenyl	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C2 Substituted dibenzothiophen	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Fluorene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
1-Methyl-7-isopropyl-phenanthi	ppb	< 0.04	< 0.04	< 0.04		< 0.04	2
Pyrene	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Total PAHs		0.05	0	0		0.05	2
Target PANHs		-	-				
quinoline	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Acridine	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Carbazole	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02		< 0.02	2
Phenolics		-	-				
Phenol	ppb	< 0.1	< 0.1	< 0.1		< 0.1	2
o-Cresol	ppb	< 0.1	< 0.1	< 0.1		< 0.1	2
m-Cresol	ppb	< 0.1	< 0.1	< 0.1		< 0.1	2
p-Cresol	ppb	< 0.1	< 0.1	< 0.1		< 0.1	2
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1		< 0.1	2
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2		< 0.2	2
4-Nitrophenol	ppb	< 2	< 2	< 2		< 2	2
2,4-Dinitrophenol	ppb	< 2	< 2	< 2		< 2	2

		Sampling for Suncor 1995 study (site AW009)					
		13-May-95	14-Aug-95				
Parameter	**Units**	**data**	**data**	**min**	**median**	**max**	**count**
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2		< 2	2
Volatile organics		-	-				
Acetone	ppb	< 100	-		< 100		1
Acrolein	ppb	< 100	-		< 100		1
Acrylonitrile	ppb	< 100	-		< 100		1
Benzene	ppb	< 1	-		< 1		1
Bromodichloromethane	ppb	< 1	-		< 1		1
Bromoform	ppb	< 1	-		< 1		1
Bromomethane	ppb	< 10	-		< 10		1
2-Butanone (MEK)	ppb	< 100	-		< 100		1
Carbon disulfide	ppb	< 1	-		< 1		1
Carbon tetrachloride	ppb	< 1	-		< 1		1
Chlorobenzene	ppb	< 1	-		< 1		1
Chloroethane	ppb	< 10	-		< 10		1
2-Chloroethyl vinyl ether	ppb	< 5	-		< 5		1
Chloroform	ppb	< 1	-		< 1		1
Chloromethane	ppb	< 10	-		< 10		1
Dibromochloromethane	ppb	< 1	-		< 1		1
Dibromomethane	ppb	< 1	-		< 1		1
1,2-Dichlorobenzene	ppb	< 1	-		< 1		1
1,3-Dichlorobenzene	ppb	< 1	-		< 1		1
1,4-Dichlorobenzene	ppb	< 1	-		< 1		1
cis-1,4-Dichloro-2-butene	ppb	< 2	-		< 2		1
trans-1,4-Dichloro-2-butene	ppb	< 5	-		< 5		1
Dichlorodifluoromethane	ppb	< 1	-		< 1		1
1,1-Dichloroethane	ppb	< 1	-		< 1		1
1,2-Dichloroethane	ppb	< 1	-		< 1		1
1,1-Dichloroethene	ppb	< 1	-		< 1		1
trans-1,2-Dichloroethene	ppb	< 1	-		< 1		1
1,2-Dichloropropane	ppb	< 1	-		< 1		1
cis-1,3-Dichloropropene	ppb	< 1	-		< 1		1
trans-1,3-Dichloropropene	ppb	< 1	-		< 1		1
Ethanol	ppb	< 100	-		< 100		1
Ethylbenzene	ppb	< 1	-		< 1		1
Ethylene dibromide	ppb	< 1	-		< 1		1
Ethyl methacrylate	ppb	< 200	-		< 200		1
2-Hexanone	ppb	< 200	-		< 200		1
Iodomethane	ppb	< 1	-		< 1		1
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-		< 200		1
Methylene chloride	ppb	< 1	-		< 1		1
Styrene	ppb	< 1	-		< 1		1
Tetrachloroethylene	ppb	< 1	-		< 1		1
1,1,2,2-Tetrachloroethane	ppb	< 5	-		< 5		1
Toluene	ppb	< 1	-		< 1		1
1,1,1-Trichloroethane	ppb	< 1	-		< 1		1
1,1,2-Trichloroethane	ppb	< 1	-		< 1		1
1,2,3-Trichloropropane	ppb	< 2	-		< 2		1
Trichloroethene	ppb	< 1	-		< 1		1
Trichlorofluoromethane	ppb	< 1	-		< 1		1
Vinyl acetate	ppb	< 100	-		< 100		1
Vinyl chloride	ppb	< 20	-		< 20		1
Xylenes	ppb	< 1	-		< 1		1

		Sampling for Shell						
		25-May-97	17-Jul-97	18-Sep-97				
Parameter	**Units**	**data**	**data**	**data**	**min**	**median**	**max**	**count**
Target PAHs and Alkylated PAHs		-	-	-				
Naphthalene	ppb	< 0.02	< 0.02	< 0.1	< 0.1	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.1	< 0.1	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.1	< 0.1	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.1	< 0.1	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chrysene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/chrysene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Benzo(a)anthracene grp		0	0	0	0	0	0	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthene/methyl ben:	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluoranthene/benzo(.	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Benzo(a)pyrene grp		0	0	0	0	0	0	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C2 Substituted dibenzothiophene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Methyl phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.1	< 0.1	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanthrene (Retene)	ppb	-	-	-				
Pyrene	ppb	< 0.02	< 0.02	< 0.05	< 0.05	< 0.02	< 0.02	3
Total PAHs		0	0	0	0	0	0	3
Target PANHs		-	-	-				
quinoline	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
7-Methyl quinoline	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
Acridine	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
Methyl acridine	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
Phenanthridine	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
Carbazole	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
Methyl carbazole	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	-	< 0.02		< 0.02	2
Phenolics		-	-	-				
Phenol	ppb	-	-	-				
o-Cresol	ppb	-	-	-				
m-Cresol	ppb	-	-	-				
p-Cresol	ppb	-	-	-				
2,4-Dimethylphenol	ppb	-	-	-				
2-Nitrophenol	ppb	-	-	-				
4-Nitrophenol	ppb	-	-	-				
2,4-Dinitrophenol	ppb	-	-	-				

WATER QUALITY FOR THE ATHABASCA RIVER UPSTREAM OF MUSKEG RIVER

Attachment 1

		Sampling for Shell						
		25-May-97	17-Jul-97	18-Sep-97				
Parameter	**Units**	**data**	**data**	**data**	**min**	**median**	**max**	**count**
4,6-Dinitro-2-methyl phenol	ppb	-	-	-				
Volatile organics		-	-	-				
Acetone	ppb	-	-	-				
Acrolein	ppb	-	-	-				
Acrylonitrile	ppb	-	-	-				
Benzene	ppb	-	-	-				
Bromodichloromethane	ppb	-	-	-				
Bromoform	ppb	-	-	-				
Bromomethane	ppb	-	-	-				
2-Butanone (MEK)	ppb	-	-	-				
Carbon disulfide	ppb	-	-	-				
Carbon tetrachloride	ppb	-	-	-				
Chlorobenzene	ppb	-	-	-				
Chloroethane	ppb	-	-	-				
2-Chloroethyl vinyl ether	ppb	-	-	-				
Chloroform	ppb	-	-	-				
Chloromethane	ppb	-	-	-				
Dibromochloromethane	ppb	-	-	-				
Dibromomethane	ppb	-	-	-				
1,2-Dichlorobenzene	ppb	-	-	-				
1,3-Dichlorobenzene	ppb	-	-	-				
1,4-Dichlorobenzene	ppb	-	-	-				
cis-1,4-Dichloro-2-butene	ppb	-	-	-				
trans-1,4-Dichloro-2-butene	ppb	-	-	-				
Dichlorodifluoromethane	ppb	-	-	-				
1,1-Dichloroethane	ppb	-	-	-				
1,2-Dichloroethane	ppb	-	-	-				
1,1-Dichloroethene	ppb	-	-	-				
trans-1,2-Dichloroethene	ppb	-	-	-				
1,2-Dichloropropane	ppb	-	-	-				
cis-1,3-Dichloropropene	ppb	-	-	-				
trans-1,3-Dichloropropene	ppb	-	-	-				
Ethanol	ppb	-	-	-				
Ethylbenzene	ppb	-	-	-				
Ethylene dibromide	ppb	-	-	-				
Ethyl methacrylate	ppb	-	-	-				
2-Hexanone	ppb	-	-	-				
Iodomethane	ppb	-	-	-				
4-Methyl-2-pentanone (MIBK)	ppb	-	-	-				
Methylene chloride	ppb	-	-	-				
Styrene	ppb	-	-	-				
Tetrachloroethylene	ppb	-	-	-				
1,1,2,2-Tetrachloroethane	ppb	-	-	-				
Toluene	ppb	-	-	-				
1,1,1-Trichloroethane	ppb	-	-	-				
1,1,2-Trichloroethane	ppb	-	-	-				
1,2,3-Trichloropropane	ppb	-	-	-				
Trichloroethene	ppb	-	-	-				
Trichlorofluoromethane	ppb	-	-	-				
Vinyl acetate	ppb	-	-	-				
Vinyl chloride	ppb	-	-	-				
Xylenes	ppb	-	-	-				

		1997 Ramp Sampling			Steepbank & Aurora EIA, Site AW010				
			Triplicates		Duplicates		Duplicates		Dupl
		27-Feb-97	27-Feb-97	27-Feb-97	31-May-95	31-May-95	7-Aug-95	7-Aug-95	11-Oct-95
Parameter	**Units**	**data**	**data**	**data**	**data**	**data**	**data**	**data**	**data**
Target PAHs and Alkylated PAHs		-	-	-	-	-	-	-	-
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd benzo(a)anthracene/(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Benzo(a)anthracene grp		0	0	0	0	0	0	0	0
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl benzo(b&k) fluoranthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Benzo(a)pyrene grp		0	0	0	0	0	0	0	0
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Substituted dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
1-Methyl-7-isopropyl-phenanthr	ppb	-	-	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Total PAHs		0	0	0	0	0	0	0	0
Target PANHs		-	-	-	-	-	-	-	-
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenolics		-	-	-	-	-	-	-	-
Phenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

		1997 Ramp Sampling			Steepbank & Aurora EIA, Site AW010				
		Triplicates			Duplicates		Duplicates		Dupl
		27-Feb-97	27-Feb-97	27-Feb-97	31-May-95	31-May-95	7-Aug-95	7-Aug-95	11-Oct-95
Parameter	**Units**	**data**	**data**	**data**	**data**	**data**	**data**	**data**	**data**
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
4-Nitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Volatile organics		-	-	-	-	-	-	-	-
Acetone	ppb	-	-	-	< 100	< 100	-	-	-
Acrolein	ppb	-	-	-	< 100	< 100	-	-	-
Acrylonitrile	ppb	-	-	-	< 100	< 100	-	-	-
Benzene	ppb	-	-	-	< 1	< 1	-	-	-
Bromodichloromethane	ppb	-	-	-	< 1	< 1	-	-	-
Bromoform	ppb	-	-	-	< 1	< 1	-	-	-
Bromomethane	ppb	-	-	-	< 10	< 10	-	-	-
2-Butanone (MEK)	ppb	-	-	-	< 100	< 100	-	-	-
Carbon disulfide	ppb	-	-	-	< 1	< 1	-	-	-
Carbon tetrachloride	ppb	-	-	-	< 1	< 1	-	-	-
Chlorobenzene	ppb	-	-	-	< 1	< 1	-	-	-
Chloroethane	ppb	-	-	-	< 10	< 10	-	-	-
2-Chloroethyl vinyl ether	ppb	-	-	-	< 5	< 5	-	-	-
Chloroform	ppb	-	-	-	< 1	< 1	-	-	-
Chloromethane	ppb	-	-	-	< 10	< 10	-	-	-
Dibromochloromethane	ppb	-	-	-	< 1	< 1	-	-	-
Dibromomethane	ppb	-	-	-	< 1	< 1	-	-	-
1,2-Dichlorobenzene	ppb	-	-	-	< 1	< 1	-	-	-
1,3-Dichlorobenzene	ppb	-	-	-	< 1	< 1	-	-	-
1,4-Dichlorobenzene	ppb	-	-	-	< 1	< 1	-	-	-
cis-1,4-Dichloro-2-butene	ppb	-	-	-	< 2	< 2	-	-	-
trans-1,4-Dichloro-2-butene	ppb	-	-	-	< 5	< 5	-	-	-
Dichlorodifluoromethane	ppb	-	-	-	< 1	< 1	-	-	-
1,1-Dichloroethane	ppb	-	-	-	< 1	< 1	-	-	-
1,2-Dichloroethane	ppb	-	-	-	< 1	< 1	-	-	-
1,1-Dichloroethene	ppb	-	-	-	< 1	< 1	-	-	-
trans-1,2-Dichloroethene	ppb	-	-	-	< 1	< 1	-	-	-
1,2-Dichloropropane	ppb	-	-	-	< 1	< 1	-	-	-
cis-1,3-Dichloropropene	ppb	-	-	-	< 1	< 1	-	-	-
trans-1,3-Dichloropropene	ppb	-	-	-	< 1	< 1	-	-	-
Ethanol	ppb	-	-	-	< 100	< 100	-	-	-
Ethylbenzene	ppb	-	-	-	< 1	< 1	-	-	-
Ethylene dibromide	ppb	-	-	-	< 1	< 1	-	-	-
Ethyl methacrylate	ppb	-	-	-	< 200	< 200	-	-	-
2-Hexanone	ppb	-	-	-	< 200	< 200	-	-	-
Iodomethane	ppb	-	-	-	< 1	< 1	-	-	-
4-Methyl-2-pentanone (MIBK)	ppb	-	-	-	< 200	< 200	-	-	-
Methylene chloride	ppb	-	-	-	< 1	< 1	-	-	-
Styrene	ppb	-	-	-	< 1	< 1	-	-	-
Tetrachloroethylene	ppb	-	-	-	< 1	< 1	-	-	-
1,1,2,2-Tetrachloroethane	ppb	-	-	-	< 5	< 5	-	-	-
Toluene	ppb	-	-	-	< 1	< 1	-	-	-
1,1,1-Trichloroethane	ppb	-	-	-	< 1	< 1	-	-	-
1,1,2-Trichloroethane	ppb	-	-	-	< 1	< 1	-	-	-
1,2,3-Trichloropropane	ppb	-	-	-	< 2	< 2	-	-	-
Trichloroethene	ppb	-	-	-	< 1	< 1	-	-	-
Trichlorofluoromethane	ppb	-	-	-	< 1	< 1	-	-	-
Vinyl acetate	ppb	-	-	-	< 100	< 100	-	-	-
Vinyl chloride	ppb	-	-	-	< 20	< 20	-	-	-
Xylenes	ppb	-	-	-	< 1	< 1	-	-	-

WATER QUALITY AT THE MOUTH OF THE STEEPBANK RIVER

Attachment 1

		icates				
		11-Oct-95				
Parameter	**Units**	**data**	**min**	**median**	**max**	**count**
Target PAHs and Alkylated PAHs		-				
Naphthalene	ppb	0.02	< 0.02	< 0.02	0.02	9
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C2 Subst'd benzo(a)anthracene/(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Benzo(a)anthracene grp		0	0	0	0	9
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl benzo(b&k) fluoranthen(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Benzo(a)pyrene grp		0	0	0	0	9
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C2 Substituted dibenzothiophen(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl phenanthrene/anthracene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C2 Subst'd phenanthrene/anthra(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C3 Subst'd phenanthrene/anthra(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
C4 Subst'd phenanthrene/anthra(	ppb	< 0.04	< 0.04	< 0.04	< 0.04	9
1-Methyl-7-isopropyl-phenanthr	ppb	< 0.04	< 0.04	< 0.04	< 0.04	6
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Total PAHs		0.02	0	0	0.02	9
Target PANHs		-				
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	9
Phenolics		-				
Phenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	9
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	9
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	9
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	9
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	9

		icates				
		11-Oct-95				
Parameter	**Units**	**data**	**min**	**median**	**max**	**count**
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	9
4-Nitrophenol	ppb	< 2	< 2	< 2	< 2	9
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 2	9
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 2	9
Volatile organics		-				
Acetone	ppb	-	< 100		< 100	2
Acrolein	ppb	-	< 100		< 100	2
Acrylonitrile	ppb	-	< 100		< 100	2
Benzene	ppb	-	< 1		< 1	2
Bromodichloromethane	ppb	-	< 1		< 1	2
Bromoform	ppb	-	< 1		< 1	2
Bromomethane	ppb	-	< 10		< 10	2
2-Butanone (MEK)	ppb	-	< 100		< 100	2
Carbon disulfide	ppb	-	< 1		< 1	2
Carbon tetrachloride	ppb	-	< 1		< 1	2
Chlorobenzene	ppb	-	< 1		< 1	2
Chloroethane	ppb	-	< 10		< 10	2
2-Chloroethyl vinyl ether	ppb	-	< 5		< 5	2
Chloroform	ppb	-	< 1		< 1	2
Chloromethane	ppb	-	< 10		< 10	2
Dibromochloromethane	ppb	-	< 1		< 1	2
Dibromomethane	ppb	-	< 1		< 1	2
1,2-Dichlorobenzene	ppb	-	< 1		< 1	2
1,3-Dichlorobenzene	ppb	-	< 1		< 1	2
1,4-Dichlorobenzene	ppb	-	< 1		< 1	2
cis-1,4-Dichloro-2-butene	ppb	-	< 2		< 2	2
trans-1,4-Dichloro-2-butene	ppb	-	< 5		< 5	2
Dichlorodifluoromethane	ppb	-	< 1		< 1	2
1,1-Dichloroethane	ppb	-	< 1		< 1	2
1,2-Dichloroethane	ppb	-	< 1		< 1	2
1,1-Dichloroethene	ppb	-	< 1		< 1	2
trans-1,2-Dichloroethene	ppb	-	< 1		< 1	2
1,2-Dichloropropane	ppb	-	< 1		< 1	2
cis-1,3-Dichloropropene	ppb	-	< 1		< 1	2
trans-1,3-Dichloropropene	ppb	-	< 1		< 1	2
Ethanol	ppb	-	< 100		< 100	2
Ethylbenzene	ppb	-	< 1		< 1	2
Ethylene dibromide	ppb	-	< 1		< 1	2
Ethyl methacrylate	ppb	-	< 200		< 200	2
2-Hexanone	ppb	-	< 200		< 200	2
Iodomethane	ppb	-	< 1		< 1	2
4-Methyl-2-pentanone (MIBK)	ppb	-	< 200		< 200	2
Methylene chloride	ppb	-	< 1		< 1	2
Styrene	ppb	-	< 1		< 1	2
Tetrachloroethylene	ppb	-	< 1		< 1	2
1,1,2,2-Tetrachloroethane	ppb	-	< 5		< 5	2
Toluene	ppb	-	< 1		< 1	2
1,1,1-Trichloroethane	ppb	-	< 1		< 1	2
1,1,2-Trichloroethane	ppb	-	< 1		< 1	2
1,2,3-Trichloropropane	ppb	-	< 2		< 2	2
Trichloroethene	ppb	-	< 1		< 1	2
Trichlorofluoromethane	ppb	-	< 1		< 1	2
Vinyl acetate	ppb	-	< 100		< 100	2
Vinyl chloride	ppb	-	< 20		< 20	2
Xylenes	ppb	-	< 1		< 1	2

		Shell 1997	Steepbank & Aurora EIA, Site 30						
		16-Mar-97	Spring	Summer	Fall				
Parameter	Units	data	data	data	data	min	median	max	count
Target PAHs and Alkylated PAHs			-	-	-				
Naphthalene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/(	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		0	-	0	0	0	0	0	3
Benzo(a)pyrene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen(	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		0	-	0	0	0	0	0	3
Benzo(b&k)fluoranthene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted biphenyl	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted dibenzothiophen(	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted fluorene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracene	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra(	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthra(	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra(	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanthr	ppb	-	-	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	2
Pyrene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Total PAHs		0	-	0	0	0	0	0	3
Target PANHs		-	-	-	-				
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	4
Phenolics		-	-	-	-				
Phenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	4

		Shell 1997	Steepbank & Aurora EIA, Site 30						
		16-Mar-97	Spring	Summer	Fall				
Parameter	**Units**	**data**	**data**	**data**	**data**	**min**	**median**	**max**	**count**
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	4
4-Nitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	< 2	4
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	< 2	4
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	< 2	4
Volatile organics		-	-	-	-				
Acetone	ppb	-	< 100	-	-		< 100		1
Acrolein	ppb	-	< 100	-	-		< 100		1
Acrylonitrile	ppb	-	< 100	-	-		< 100		1
Benzene	ppb	-	< 1	-	-		< 1		1
Bromodichloromethane	ppb	-	< 1	-	-		< 1		1
Bromoform	ppb	-	< 1	-	-		< 1		1
Bromomethane	ppb	-	< 10	-	-		< 10		1
2-Butanone (MEK)	ppb	-	< 100	-	-		< 100		1
Carbon disulfide	ppb	-	< 1	-	-		< 1		1
Carbon tetrachloride	ppb	-	< 1	-	-		< 1		1
Chlorobenzene	ppb	-	< 1	-	-		< 1		1
Chloroethane	ppb	-	< 10	-	-		< 10		1
2-Chloroethyl vinyl ether	ppb	-	< 5	-	-		< 5		1
Chloroform	ppb	-	< 1	-	-		< 1		1
Chloromethane	ppb	-	< 10	-	-		< 10		1
Dibromochloromethane	ppb	-	< 1	-	-		< 1		1
Dibromomethane	ppb	-	< 1	-	-		< 1		1
1,2-Dichlorobenzene	ppb	-	< 1	-	-		< 1		1
1,3-Dichlorobenzene	ppb	-	< 1	-	-		< 1		1
1,4-Dichlorobenzene	ppb	-	< 1	-	-		< 1		1
cis-1,4-Dichloro-2-butene	ppb	-	< 2	-	-		< 2		1
trans-1,4-Dichloro-2-butene	ppb	-	< 5	-	-		< 5		1
Dichlorodifluoromethane	ppb	-	< 1	-	-		< 1		1
1,1-Dichloroethane	ppb	-	< 1	-	-		< 1		1
1,2-Dichloroethane	ppb	-	< 1	-	-		< 1		1
1,1-Dichloroethene	ppb	-	< 1	-	-		< 1		1
trans-1,2-Dichloroethene	ppb	-	< 1	-	-		< 1		1
1,2-Dichloropropane	ppb	-	< 1	-	-		< 1		1
cis-1,3-Dichloropropene	ppb	-	< 1	-	-		< 1		1
trans-1,3-Dichloropropene	ppb	-	< 1	-	-		< 1		1
Ethanol	ppb	-	< 100	-	-		< 100		1
Ethylbenzene	ppb	-	< 1	-	-		< 1		1
Ethylene dibromide	ppb	-	< 1	-	-		< 1		1
Ethyl methacrylate	ppb	-	< 200	-	-		< 200		1
2-Hexanone	ppb	-	< 200	-	-		< 200		1
Iodomethane	ppb	-	< 1	-	-		< 1		1
4-Methyl-2-pentanone (MIBK)	ppb	-	< 200	-	-		< 200		1
Methylene chloride	ppb	-	< 1	-	-		< 1		1
Styrene	ppb	-	< 1	-	-		< 1		1
Tetrachloroethylene	ppb	-	< 1	-	-		< 1		1
1,1,2,2-Tetrachloroethane	ppb	-	< 5	-	-		< 5		1
Toluene	ppb	-	< 1	-	-		< 1		1
1,1,1-Trichloroethane	ppb	-	< 1	-	-		< 1		1
1,1,2-Trichloroethane	ppb	-	< 1	-	-		< 1		1
1,2,3-Trichloropropane	ppb	-	< 2	-	-		< 2		1
Trichloroethene	ppb	-	< 1	-	-		< 1		1
Trichlorofluoromethane	ppb	-	< 1	-	-		< 1		1
Vinyl acetate	ppb	-	< 100	-	-		< 100		1
Vinyl chloride	ppb	-	< 20	-	-		< 20		1
Xylenes	ppb	-	< 1	-	-		< 1		1

		Collected for Steepbank and Aurora EIAs						
		Spring	Summer	Fall				
Parameter	**Units**	**data**	**data**	**data**	**min**	**median**	**max**	**count**
Target PAHs and Alkylated PAHs		-	-	-				
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		0	0	0	0	0	0	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluorar	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		0	0	0	0	0	0	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted dibenzothiophen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Substituted fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanthi	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Total PAHs		0	0	0	0	0	0	3
Target PANHs		-	-	-				
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenolics		-	-	-				
Phenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3

		Collected for Steepbank and Aurora EIAs						
		Spring	Summer	Fall				
Parameter	Units	data	data	data	min	median	max	count
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3
4-Nitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
Volatile organics		-	-	-				
Acetone	ppb	< 100	-	-	< 100	< 100	< 100	1
Acrolein	ppb	< 100	-	-	< 100	< 100	< 100	1
Acrylonitrile	ppb	< 100	-	-	< 100	< 100	< 100	1
Benzene	ppb	< 1	-	-	< 1	< 1	< 1	1
Bromodichloromethane	ppb	< 1	-	-	< 1	< 1	< 1	1
Bromoform	ppb	< 1	-	-	< 1	< 1	< 1	1
Bromomethane	ppb	< 10	-	-	< 10	< 10	< 10	1
2-Butanone (MEK)	ppb	< 100	-	-	< 100	< 100	< 100	1
Carbon disulfide	ppb	< 1	-	-	< 1	< 1	< 1	1
Carbon tetrachloride	ppb	< 1	-	-	< 1	< 1	< 1	1
Chlorobenzene	ppb	< 1	-	-	< 1	< 1	< 1	1
Chloroethane	ppb	< 10	-	-	< 10	< 10	< 10	1
2-Chloroethyl vinyl ether	ppb	< 5	-	-	< 5	< 5	< 5	1
Chloroform	ppb	< 1	-	-	< 1	< 1	< 1	1
Chloromethane	ppb	< 10	-	-	< 10	< 10	< 10	1
Dibromochloromethane	ppb	< 1	-	-	< 1	< 1	< 1	1
Dibromomethane	ppb	< 1	-	-	< 1	< 1	< 1	1
1,2-Dichlorobenzene	ppb	< 1	-	-	< 1	< 1	< 1	1
1,3-Dichlorobenzene	ppb	< 1	-	-	< 1	< 1	< 1	1
1,4-Dichlorobenzene	ppb	< 1	-	-	< 1	< 1	< 1	1
cis-1,4-Dichloro-2-butene	ppb	< 2	-	-	< 2	< 2	< 2	1
trans-1,4-Dichloro-2-butene	ppb	< 5	-	-	< 5	< 5	< 5	1
Dichlorodifluoromethane	ppb	< 1	-	-	< 1	< 1	< 1	1
1,1-Dichloroethane	ppb	< 1	-	-	< 1	< 1	< 1	1
1,2-Dichloroethane	ppb	< 1	-	-	< 1	< 1	< 1	1
1,1-Dichloroethene	ppb	< 1	-	-	< 1	< 1	< 1	1
trans-1,2-Dichloroethene	ppb	< 1	-	-	< 1	< 1	< 1	1
1,2-Dichloropropane	ppb	< 1	-	-	< 1	< 1	< 1	1
cis-1,3-Dichloropropene	ppb	< 1	-	-	< 1	< 1	< 1	1
trans-1,3-Dichloropropene	ppb	< 1	-	-	< 1	< 1	< 1	1
Ethanol	ppb	< 100	-	-	< 100	< 100	< 100	1
Ethylbenzene	ppb	< 1	-	-	< 1	< 1	< 1	1
Ethylene dibromide	ppb	< 1	-	-	< 1	< 1	< 1	1
Ethyl methacrylate	ppb	< 200	-	-	< 200	< 200	< 200	1
2-Hexanone	ppb	< 200	-	-	< 200	< 200	< 200	1
Iodomethane	ppb	< 1	-	-	< 1	< 1	< 1	1
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	-	< 200	< 200	< 200	1
Methylene chloride	ppb	< 1	-	-	< 1	< 1	< 1	1
Styrene	ppb	< 1	-	-	< 1	< 1	< 1	1
Tetrachloroethylene	ppb	< 1	-	-	< 1	< 1	< 1	1
1,1,2,2-Tetrachloroethane	ppb	< 5	-	-	< 5	< 5	< 5	1
Toluene	ppb	< 1	-	-	< 1	< 1	< 1	1
1,1,1-Trichloroethane	ppb	< 1	-	-	< 1	< 1	< 1	1
1,1,2-Trichloroethane	ppb	< 1	-	-	< 1	< 1	< 1	1
1,2,3-Trichloropropane	ppb	< 2	-	-	< 2	< 2	< 2	1
Trichloroethene	ppb	< 1	-	-	< 1	< 1	< 1	1
Trichlorofluoromethane	ppb	< 1	-	-	< 1	< 1	< 1	1
Vinyl acetate	ppb	< 100	-	-	< 100	< 100	< 100	1
Vinyl chloride	ppb	< 20	-	-	< 20	< 20	< 20	1
Xylenes	ppb	< 1	-	-	< 1	< 1	< 1	1

North Mine Drainage **Attachment 1**

- This data originated from sample site RW250, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	10-Jul-95 data	27-Jul-95 data	14-Aug-95 data	29-Aug-95 data	11-Sep-95 data		min	median	max	count
Target PAHs and Alkylated PAHs		-	-	-	-	-					
Naphthalene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/(	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		-	0	0	-	0	0	0	0	0	3
Benzo(a)pyrene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen(	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluoran	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		-	0	0	-	0	0	0	0	0	3
Benzo(b&k)fluoranthene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C2 Subst'd biphenyl	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C2 Subst'd dibenzothiophene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C2 Subst'd fluorene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracene	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra(	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthra(	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra(	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanthr	ppb	-	< 0.04	< 0.04	-	< 0.04		< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Total PAHs		-	0	0	-	0	0	0	0	0	3
Target PANHs		-	-	-	-	-					
quinoline	ppb	-	< 0.02	-	-	-			< 0.02		1
7-Methyl quinoline	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Acridine	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	-	< 0.02	< 0.02	-	< 0.02		< 0.02	< 0.02	< 0.02	3
Phenolics		-	-	-	-	-					
Phenol	ppb	-	< 0.1	< 0.1	-	< 0.1		< 0.1	< 0.1	< 0.1	3
o-Cresol	ppb	-	< 0.1	< 0.1	-	< 0.1		< 0.1	< 0.1	< 0.1	3
m-Cresol	ppb	-	< 0.1	< 0.1	-	< 0.1		< 0.1	< 0.1	< 0.1	3
p-Cresol	ppb	-	< 0.1	< 0.1	-	< 0.1		< 0.1	< 0.1	< 0.1	3
2,4-Dimethylphenol	ppb	-	< 0.1	< 0.1	-	< 0.1		< 0.1	< 0.1	< 0.1	3
2-Nitrophenol	ppb	-	< 0.2	< 0.2	-	< 0.2		< 0.2	< 0.2	< 0.2	3
4-Nitrophenol	ppb	-	< 2	< 2	-	< 2		< 2	< 2	< 2	3
2,4-Dinitrophenol	ppb	-	< 2	< 2	-	< 2		< 2	< 2	< 2	3
4,6-Dinitro-2-methyl phenol	ppb	-	< 2	< 2	-	< 2		< 2	< 2	< 2	3

North Mine Drainage **Attachment 1**

- This data originated from sample site RW250, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	10-Jul-95 data	27-Jul-95 data	14-Aug-95 data	29-Aug-95 data	11-Sep-95 data	min	median	max	count
Volatile organics		-	-	-	-	-				
Acetone	ppb	< 100	< 100	-	< 100	-	< 100	< 100	< 100	3
Acrolein	ppb	< 100	< 100	-	< 100	-	< 100	< 100	< 100	3
Acrylonitrile	ppb	< 100	< 100	-	< 100	-	< 100	< 100	< 100	3
Benzene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Bromodichloromethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Bromoform	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Bromomethane	ppb	< 10	< 10	-	< 10	-	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	< 100	< 100	-	< 100	-	< 100	< 100	< 100	3
Carbon disulfide	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Chlorobenzene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Chloroethane	ppb	< 10	< 10	-	< 10	-	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	< 5	< 5	-	< 5	-	< 5	< 5	< 5	3
Chloroform	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Chloromethane	ppb	< 10	< 10	-	< 10	-	< 10	< 10	< 10	3
Dibromochloromethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Dibromomethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	< 2	< 2	-	< 2	-	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	< 5	< 5	-	< 5	-	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Ethanol	ppb	< 100	< 100	-	< 100	-	< 100	< 100	< 100	3
Ethylbenzene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Ethylene dibromide	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	< 200	< 200	-	< 200	-	< 200	< 200	< 200	3
2-Hexanone	ppb	< 200	< 200	-	< 200	-	< 200	< 200	< 200	3
Iodomethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	< 200	< 200	-	< 200	-	< 200	< 200	< 200	3
Methylene chloride	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Styrene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	< 5	< 5	-	< 5	-	< 5	< 5	< 5	3
Toluene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	< 2	< 2	-	< 2	-	< 2	< 2	< 2	3
Trichloroethene	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	< 1	< 1	-	< 1	-	< 1	< 1	< 1	3
Vinyl acetate	ppb	< 100	< 100	-	< 100	-	< 100	< 100	< 100	3
Vinyl chloride	ppb	< 20	< 20	-	-	-	< 20		< 20	2
m+p-Xylenes	ppb	< 1	2.9	-	< 1	-	< 1	< 1	2.9	3
o-Xylene	ppb	< 1	1.3	-	< 1	-	< 1	< 1	1.3	3

Middle Mine Drainage **Attachment 1**

- this data originated from sample site RW251, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	10-Jul-95 data	31-Jul-95 data	9-Aug-95 data	15-Aug-95 data	29-Aug-95 data	min	median	max	count
Target PAHs and Alkylated PAHs		-	-	-	-	-				
Naphthalene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl naphthalenes	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
C2 Subst'd naphthalenes	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C3 Subst'd naphthalenes	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C4 Subst'd naphthalenes	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Acenaphthene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl acenaphthene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Acenaphthylene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Anthracene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Dibenzo(a,h)anthracene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Benzo(a)Anthracene/Chrysene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl benzo(a)anthracene/chry	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C2 Subst'd benzo(a)anthracene/c	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Benzo(a)anthracene grp		-	0	-	0	-	0		0	2
Benzo(a)pyrene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl benzo(b&k) fluoranthene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C2 Subst'd benzo(b& k) fluoran	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Benzo(a)pyrene grp		-	0	-	0	-	0		0	2
Benzo(b&k)fluoranthene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Benzo(g,h,i)perylene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Biphenyl	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Methyl biphenyl	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C2 Subst'd biphenyl	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Dibenzothiophene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl dibenzothiophene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C2 Subst'd dibenzothiophene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C3 Subst'd dibenzothiophene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C4 Subst'd dibenzothiophene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Fluoranthene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl fluoranthene/pyrene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Fluorene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl fluorene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C2 Subst'd fluorene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Indeno(c,d-123)pyrene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Phenanthrene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl phenanthrene/anthracene	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C2 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C3 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
C4 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
1-Methyl-7-isopropyl-phenanthr	ppb	-	< 0.04	-	< 0.04	-	< 0.04		< 0.04	2
Pyrene	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Total PAHs		-	0	-	0	-	0		0	2
Target PANHs		-	-	-	-	-				
quinoline	ppb	-	< 0.02	-	-	-		< 0.02		1
7-Methyl quinoline	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
C2 Subst'd quinoline	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
C3 Subst'd quinoline	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Acridine	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl acridine	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Phenanthridine	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Carbazole	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Methyl carbazole	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
C2 Subst'd carbazole	ppb	-	< 0.02	-	< 0.02	-	< 0.02		< 0.02	2
Phenolics		-	-	-	-	-				
Phenol	ppb	-	< 0.1	-	< 0.1	-	< 0.1		< 0.1	2
o-Cresol	ppb	-	< 0.1	-	< 0.1	-	< 0.1		< 0.1	2
m-Cresol	ppb	-	< 0.1	-	0.2	-	< 0.1		0.2	2
p-Cresol	ppb	-	< 0.1	-	< 0.1	-	< 0.1		< 0.1	2
2,4-Dimethylphenol	ppb	-	< 0.1	-	< 0.1	-	< 0.1		< 0.1	2
2-Nitrophenol	ppb	-	< 0.2	-	< 0.2	-	< 0.2		< 0.2	2
4-Nitrophenol	ppb	-	< 2	-	< 2	-	< 2		< 2	2
2,4-Dinitrophenol	ppb	-	< 2	-	< 2	-	< 2		< 2	2
4,6-Dinitro-2-methyl phenol	ppb	-	< 2	-	< 2	-	< 2		< 2	2

Middle Mine Drainage

Attachment 1

- this data originated from sample site RW251, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	10-Jul-95 data	31-Jul-95 data	9-Aug-95 data	15-Aug-95 data	29-Aug-95 data	min	median	max	count
Volatile organics		-	-	-	-	-				
Acetone	ppb	< 100	-	< 100	-	< 100	< 100	< 100	< 100	3
Acrolein	ppb	< 100	-	< 100	-	< 100	< 100	< 100	< 100	3
Acrylonitrile	ppb	< 100	-	< 100	-	< 100	< 100	< 100	< 100	3
Benzene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Bromodichloromethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Bromoform	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Bromomethane	ppb	< 10	-	< 10	-	< 10	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	< 100	-	< 100	-	< 100	< 100	< 100	< 100	3
Carbon disulfide	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Chlorobenzene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Chloroethane	ppb	< 10	-	< 10	-	< 10	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	< 5	-	< 5	-	< 5	< 5	< 5	< 5	3
Chloroform	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Chloromethane	ppb	< 10	-	< 10	-	< 10	< 10	< 10	< 10	3
Dibromochloromethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Dibromomethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	< 2	-	< 2	-	< 2	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	< 5	-	< 5	-	< 5	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Ethanol	ppb	< 100	-	< 100	-	< 100	< 100	< 100	< 100	3
Ethylbenzene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Ethylene dibromide	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	< 200	-	< 200	-	< 200	< 200	< 200	< 200	3
2-Hexanone	ppb	< 200	-	< 200	-	< 200	< 200	< 200	< 200	3
Iodomethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	< 200	-	< 200	< 200	< 200	< 200	3
Methylene chloride	ppb	< 1	-	< 1	-	4	< 1	< 1	4	3
Styrene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	< 5	-	< 5	-	< 5	< 5	< 5	< 5	3
Toluene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	< 2	-	< 2	-	< 2	< 2	< 2	< 2	3
Trichloroethene	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	< 1	-	< 1	-	< 1	< 1	< 1	< 1	3
Vinyl acetate	ppb	< 100	-	< 100	-	< 100	< 100	< 100	< 100	3
Vinyl chloride	ppb	< 20	-	< 20	-	< 20	< 20	< 20	< 20	3
m+p-Xylenes	ppb	< 1	-	2.4	-	< 1	< 1	< 1	2.4	3
o-Xylene	ppb	< 1	-	1	-	< 1	< 1	< 1	1	3

South Mine Drainage **Attachment 1**

- this data originated from sample site RW252, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	14-Jul-95 data	27-Jul-95 data	31-Jul-95 data	9-Aug-95 data	20-Aug-95 data	7-Sep-95 data	11-Sep-95 data
Target PAHs and Alkylated PAHs		-	-	-	-	-	-	-
Naphthalene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl naphthalenes	ppb	-	< 0.02	-	-	< 0.02	-	-
C2 Subst'd naphthalenes	ppb	-	< 0.04	-	-	< 0.04	-	-
C3 Subst'd naphthalenes	ppb	-	< 0.04	-	-	< 0.04	-	-
C4 Subst'd naphthalenes	ppb	-	< 0.04	-	-	< 0.04	-	-
Acenaphthene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl acenaphthene	ppb	-	< 0.04	-	-	< 0.04	-	-
Acenaphthylene	ppb	-	< 0.02	-	-	< 0.02	-	-
Anthracene	ppb	-	< 0.02	-	-	< 0.02	-	-
Dibenzo(a,h)anthracene	ppb	-	< 0.02	-	-	< 0.02	-	-
Benzo(a)Anthracene/Chrysene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl benzo(a)anthracene/chry	ppb	-	< 0.04	-	-	< 0.04	-	-
C2 Subst'd benzo(a)anthracene/	ppb	-	< 0.04	-	-	< 0.04	-	-
Benzo(a)anthracene grp		-	0	-	-	0	-	-
Benzo(a)pyrene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl benzo(b&k) fluoranthen	ppb	-	< 0.04	-	-	< 0.04	-	-
C2 Subst'd benzo(b& k) fluorar	ppb	-	< 0.04	-	-	< 0.04	-	-
Benzo(a)pyrene grp		-	0	-	-	0	-	-
Benzo(b&k)fluoranthene	ppb	-	< 0.02	-	-	< 0.02	-	-
Benzo(g,h,i)perylene	ppb	-	< 0.02	-	-	< 0.02	-	-
Biphenyl	ppb	-	< 0.04	-	-	< 0.04	-	-
Methyl biphenyl	ppb	-	< 0.04	-	-	< 0.04	-	-
C2 Subst'd biphenyl	ppb	-	< 0.04	-	-	< 0.04	-	-
Dibenzothiophene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl dibenzothiophene	ppb	-	< 0.04	-	-	< 0.04	-	-
C2 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	< 0.04	-	-
C3 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	< 0.04	-	-
C4 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	< 0.04	-	-
Fluoranthene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl fluoranthene/pyrene	ppb	-	< 0.04	-	-	< 0.04	-	-
Fluorene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl fluorene	ppb	-	< 0.04	-	-	< 0.04	-	-
C2 Subst'd fluorene	ppb	-	< 0.04	-	-	< 0.04	-	-
Indeno(c,d-123)pyrene	ppb	-	< 0.02	-	-	< 0.02	-	-
Phenanthrene	ppb	-	< 0.02	-	-	< 0.02	-	-
Methyl phenanthrene/anthracen	ppb	-	< 0.04	-	-	< 0.04	-	-
C2 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	< 0.04	-	-
C3 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	< 0.04	-	-
C4 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	< 0.04	-	-
1-Methyl-7-isopropyl-phenanthi	ppb	-	< 0.04	-	-	< 0.04	-	-
Pyrene	ppb	-	-	-	-	< 0.02	-	-
Total PAHs		-	0	-	-	0	-	-
Target PANHs		-	-	-	-	-	-	-
quinoline	ppb	-	-	< 0.02	-	-	-	-
7-Methyl quinoline	ppb	-	-	< 0.02	-	< 0.02	-	-
C2 Subst'd quinoline	ppb	-	-	< 0.02	-	< 0.02	-	-
C3 Subst'd quinoline	ppb	-	-	< 0.02	-	< 0.02	-	-
Acridine	ppb	-	-	< 0.02	-	< 0.02	-	-
Methyl acridine	ppb	-	-	< 0.02	-	< 0.02	-	-
Phenanthridine	ppb	-	-	< 0.02	-	< 0.02	-	-
Carbazole	ppb	-	-	< 0.02	-	< 0.02	-	-
Methyl carbazole	ppb	-	-	< 0.02	-	< 0.02	-	-
C2 Subst'd carbazole	ppb	-	-	< 0.02	-	< 0.02	-	-
Phenolics		-	-	-	-	-	-	-
Phenol	ppb	-	< 0.1	-	-	-	-	-
o-Cresol	ppb	-	< 0.1	-	-	-	-	< 0.1
m-Cresol	ppb	-	< 0.1	-	-	-	-	< 0.1
p-Cresol	ppb	-	< 0.1	-	-	-	-	< 0.1

South Mine Drainage **Attachment 1**

- this data originated from sample site RW252, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	14-Jul-95 data	27-Jul-95 data	31-Jul-95 data	9-Aug-95 data	20-Aug-95 data	7-Sep-95 data	11-Sep-95 data
2,4-Dimethylphenol	ppb	-	< 0.1	-	-	-	-	< 0.1
2-Nitrophenol	ppb	-	< 0.2	-	-	-	-	< 0.2
4-Nitrophenol	ppb	-	< 2	-	-	-	-	< 2
2,4-Dinitrophenol	ppb	-	< 2	-	-	-	-	< 2
4,6-Dinitro-2-methyl phenol	ppb	-	< 2	-	-	-	-	< 2
Volatile organics		-	-	-	-	-	-	-
Acetone	ppb	< 100	-	-	< 100	-	< 100	-
Acrolein	ppb	< 100	-	-	< 100	-	< 100	-
Acrylonitrile	ppb	< 100	-	-	< 100	-	< 100	-
Benzene	ppb	< 1	-	-	< 1	-	< 1	-
Bromodichloromethane	ppb	< 1	-	-	< 1	-	< 1	-
Bromoform	ppb	< 1	-	-	< 1	-	< 1	-
Bromomethane	ppb	< 10	-	-	< 10	-	< 10	-
2-Butanone (MEK)	ppb	< 100	-	-	< 100	-	< 100	-
Carbon disulfide	ppb	< 1	-	-	< 1	-	< 1	-
Carbon tetrachloride	ppb	< 1	-	-	< 1	-	< 1	-
Chlorobenzene	ppb	< 1	-	-	< 1	-	< 1	-
Chloroethane	ppb	< 10	-	-	< 10	-	< 10	-
2-Chloroethyl vinyl ether	ppb	< 5	-	-	< 5	-	< 5	-
Chloroform	ppb	< 1	-	-	< 1	-	< 1	-
Chloromethane	ppb	< 10	-	-	< 10	-	< 10	-
Dibromochloromethane	ppb	< 1	-	-	< 1	-	< 1	-
Dibromomethane	ppb	< 1	-	-	< 1	-	< 1	-
1,2-Dichlorobenzene	ppb	< 1	-	-	< 1	-	< 1	-
1,3-Dichlorobenzene	ppb	< 1	-	-	< 1	-	< 1	-
1,4-Dichlorobenzene	ppb	< 1	-	-	< 1	-	< 1	-
cis-1,4-Dichloro-2-butene	ppb	< 2	-	-	< 2	-	< 2	-
trans-1,4-Dichloro-2-butene	ppb	< 5	-	-	< 5	-	< 5	-
Dichlorodifluoromethane	ppb	< 1	-	-	< 1	-	< 1	-
1,1-Dichloroethane	ppb	< 1	-	-	< 1	-	< 1	-
1,2-Dichloroethane	ppb	< 1	-	-	< 1	-	< 1	-
1,1-Dichloroethene	ppb	< 1	-	-	< 1	-	< 1	-
trans-1,2-Dichloroethene	ppb	< 1	-	-	< 1	-	< 1	-
1,2-Dichloropropane	ppb	< 1	-	-	< 1	-	< 1	-
cis-1,3-Dichloropropene	ppb	< 1	-	-	< 1	-	< 1	-
trans-1,3-Dichloropropene	ppb	< 1	-	-	< 1	-	< 1	-
Ethanol	ppb	< 100	-	-	< 100	-	< 100	-
Ethylbenzene	ppb	< 1	-	-	1	-	< 1	-
Ethylene dibromide	ppb	< 1	-	-	< 1	-	< 1	-
Ethyl methacrylate	ppb	< 200	-	-	< 200	-	< 200	-
2-Hexanone	ppb	< 200	-	-	< 200	-	< 200	-
Iodomethane	ppb	< 1	-	-	< 1	-	< 1	-
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	-	< 200	-	< 200	-
Methylene chloride	ppb	< 1	-	-	< 1	-	< 1	-
Styrene	ppb	< 1	-	-	< 1	-	< 1	-
Tetrachloroethylene	ppb	< 1	-	-	< 1	-	< 1	-
1,1,2,2-Tetrachloroethane	ppb	< 5	-	-	< 5	-	< 5	-
Toluene	ppb	< 1	-	-	< 1	-	< 1	-
1,1,1-Trichloroethane	ppb	< 1	-	-	< 1	-	< 1	-
1,1,2-Trichloroethane	ppb	< 1	-	-	< 1	-	< 1	-
1,2,3-Trichloropropane	ppb	< 2	-	-	< 2	-	< 2	-
Trichloroethene	ppb	< 1	-	-	< 1	-	< 1	-
Trichlorofluoromethane	ppb	< 1	-	-	< 1	-	< 1	-
Vinyl acetate	ppb	< 100	-	-	< 100	-	< 100	-
Vinyl chloride	ppb	-	-	-	-	-	-	-
m+p-Xylenes	ppb	< 1	-	-	4.1	-	< 1	-
o-Xylene	ppb	< 1	-	-	1.7	-	< 1	-

South Mine Drainage

- this data originated from sample site RW252, as described in Suncor's Lease 86 1995 reclamation program

Attachment 1

Parameter	Units	13-Sep-95 data	min	median	max	count
Target PAHs and Alkylated PAHs		-				
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		0	0	0	0	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluorar	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		0	0	0	0	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanth	ppb	< 0.04	< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	2
Total PAHs		0	0	0	0	3
Target PANHs		-				
quinoline	ppb	-		< 0.02		1
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenolics		-				
Phenol	ppb	-		< 0.1		1
o-Cresol	ppb	-	< 0.1	< 0.1	< 0.1	2
m-Cresol	ppb	-	< 0.1	< 0.1	< 0.1	2
p-Cresol	ppb	-	< 0.1	< 0.1	< 0.1	2

South Mine Drainage Attachment 1

- this data originated from sample site RW252, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	13-Sep-95 data	min	median	max	count
2,4-Dimethylphenol	ppb	-	< 0.1	< 0.1	< 0.1	2
2-Nitrophenol	ppb	-	< 0.2	< 0.2	< 0.2	2
4-Nitrophenol	ppb	-	< 2	< 2	< 2	2
2,4-Dinitrophenol	ppb	-	< 2	< 2	< 2	2
4,6-Dinitro-2-methyl phenol	ppb	-	< 2	< 2	< 2	2
Volatile organics		-				
Acetone	ppb	-	< 100	< 100	< 100	3
Acrolein	ppb	-	< 100	< 100	< 100	3
Acrylonitrile	ppb	-	< 100	< 100	< 100	3
Benzene	ppb	-	< 1	< 1	< 1	3
Bromodichloromethane	ppb	-	< 1	< 1	< 1	3
Bromoform	ppb	-	< 1	< 1	< 1	3
Bromomethane	ppb	-	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	-	< 100	< 100	< 100	3
Carbon disulfide	ppb	-	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	-	< 1	< 1	< 1	3
Chlorobenzene	ppb	-	< 1	< 1	< 1	3
Chloroethane	ppb	-	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	-	< 5	< 5	< 5	3
Chloroform	ppb	-	< 1	< 1	< 1	3
Chloromethane	ppb	-	< 10	< 10	< 10	3
Dibromochloromethane	ppb	-	< 1	< 1	< 1	3
Dibromomethane	ppb	-	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	-	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	-	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	-	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	-	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	-	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	-	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	-	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	-	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	-	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	-	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	-	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	-	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	-	< 1	< 1	< 1	3
Ethanol	ppb	-	< 100	< 100	< 100	3
Ethylbenzene	ppb	-	< 1	< 1	1.2	3
Ethylene dibromide	ppb	-	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	-	< 200	< 200	< 200	3
2-Hexanone	ppb	-	< 200	< 200	< 200	3
Iodomethane	ppb	-	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	-	< 200	< 200	< 200	3
Methylene chloride	ppb	-	< 1	< 1	< 1	3
Styrene	ppb	-	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	-	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	-	< 5	< 5	< 5	3
Toluene	ppb	-	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	-	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	-	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	-	< 2	< 2	< 2	3
Trichloroethene	ppb	-	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	-	< 1	< 1	< 1	3
Vinyl acetate	ppb	-	< 100	< 100	< 100	3
Vinyl chloride	ppb	-				
m+p-Xylenes	ppb	-	< 1	< 1	4.1	3
o-Xylene	ppb	-	< 1	< 1	1.7	3

TID Seepage **Attachment 1**

- this data originated from sample site RW127, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	14-Jul-95 data	27-Jul-95 data	31-Jul-95 data	9-Aug-95 data	18-Aug-95 data	20-Aug-95 data	31-Aug-95 data	10-Sep-95 data
Target PAHs and Alkylated PAHs		-	-	-	-	-	-	-	-
Naphthalene	ppb	-	< 0.02	-	-	-	0.09	-	< 0.02
Methyl naphthalenes	ppb	-	< 0.02	-	-	-	0.05	-	< 0.02
C2 Subst'd naphthalenes	ppb	-	0.07	-	-	-	< 0.04	-	< 0.04
C3 Subst'd naphthalenes	ppb	-	< 0.04	-	-	-	< 0.04	-	0.27
C4 Subst'd naphthalenes	ppb	-	< 0.04	-	-	-	0.07	-	0.56
Acenaphthene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl acenaphthene	ppb	-	< 0.04	-	-	-	< 0.04	-	0.28
Acenaphthylene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Anthracene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Dibenzo(a,h)anthracene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Benzo(a)Anthracene/Chrysene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl benzo(a)anthracene/chry	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
C2 Subst'd benzo(a)anthracene/	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
Benzo(a)anthracene grp		-	0	-	-	-	0	-	0
Benzo(a)pyrene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl benzo(b&k) fluoranthen	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
C2 Subst'd benzo(b& k) fluorar	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
Benzo(a)pyrene grp		-	0	-	-	-	0	-	0
Benzo(b&k)fluoranthene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Benzo(g,h,i)perylene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Biphenyl	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
Methyl biphenyl	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
C2 Subst'd biphenyl	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
Dibenzothiophene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	-	0.05
C2 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
C3 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
C4 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
Fluoranthene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl fluoranthene/pyrene	ppb	-	0.08	-	-	-	< 0.04	-	< 0.04
Fluorene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl fluorene	ppb	-	< 0.04	-	-	-	< 0.04	-	0.26
C2 Subst'd fluorene	ppb	-	< 0.04	-	-	-	< 0.04	-	0.28
Indeno(c,d-123)pyrene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Phenanthrene	ppb	-	< 0.02	-	-	-	< 0.02	-	< 0.02
Methyl phenanthrene/anthracen	ppb	-	< 0.04	-	-	-	< 0.04	-	0.07
C2 Subst'd phenanthrene/anthra	ppb	-	0.06	-	-	-	< 0.04	-	0.06
C3 Subst'd phenanthrene/anthra	ppb	-	0.12	-	-	-	0.09	-	0.06
C4 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	-	0.06	-	< 0.04
1-Methyl-7-isopropyl-phenanthi	ppb	-	< 0.04	-	-	-	< 0.04	-	< 0.04
Pyrene	ppb	-	-	-	-	-	< 0.02	-	< 0.02
Total PAHs		-	0.33	-	-	-	0.36	-	1.89
Target PANHs		-	-	-	-	-	-	-	-
quinoline	ppb	-	-	< 0.02	-	-	-	-	-
7-Methyl quinoline	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
C2 Subst'd quinoline	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
C3 Subst'd quinoline	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
Acridine	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
Methyl acridine	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
Phenanthridine	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
Carbazole	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
Methyl carbazole	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
C2 Subst'd carbazole	ppb	-	-	< 0.02	-	-	< 0.02	-	< 0.02
Phenolics		-	-	-	-	-	-	-	-
Phenol	ppb	-	< 0.1	-	-	-	-	-	-
o-Cresol	ppb	-	< 0.1	-	-	< 0.2	-	-	-
m-Cresol	ppb	-	< 0.1	-	-	< 0.2	-	-	-
p-Cresol	ppb	-	< 0.1	-	-	< 0.2	-	-	-
2,4-Dimethylphenol	ppb	-	< 1	-	-	< 0.2	-	-	-
2-Nitrophenol	ppb	-	< 2	-	-	< 0.4	-	-	-

TID Seepage Attachment 1

- this data originated from sample site RW127, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	14-Jul-95 data	27-Jul-95 data	31-Jul-95 data	9-Aug-95 data	18-Aug-95 data	20-Aug-95 data	31-Aug-95 data	10-Sep-95 data
4-Nitrophenol	ppb	-	< 20	-	-	< 4	-	-	-
2,4-Dinitrophenol	ppb	-	< 20	-	-	< 4	-	-	-
4,6-Dinitro-2-methyl phenol	ppb	-	< 20	-	-	< 4	-	-	-
Volatile organics		-	-	-	-	-	-	-	-
Acetone	ppb	< 100	-	-	< 100	-	-	< 100	-
Acrolein	ppb	< 100	-	-	< 100	-	-	< 100	-
Acrylonitrile	ppb	< 100	-	-	< 100	-	-	< 100	-
Benzene	ppb	< 1	-	-	< 1	-	-	< 1	-
Bromodichloromethane	ppb	< 1	-	-	< 1	-	-	< 1	-
Bromoform	ppb	< 1	-	-	< 1	-	-	< 1	-
Bromomethane	ppb	< 10	-	-	< 10	-	-	< 10	-
2-Butanone (MEK)	ppb	< 100	-	-	< 100	-	-	< 100	-
Carbon disulfide	ppb	< 1	-	-	< 1	-	-	< 1	-
Carbon tetrachloride	ppb	< 1	-	-	< 1	-	-	< 1	-
Chlorobenzene	ppb	< 1	-	-	< 1	-	-	< 1	-
Chloroethane	ppb	< 10	-	-	< 10	-	-	< 10	-
2-Chloroethyl vinyl ether	ppb	< 5	-	-	< 5	-	-	< 5	-
Chloroform	ppb	< 1	-	-	< 1	-	-	< 1	-
Chloromethane	ppb	< 10	-	-	< 10	-	-	< 10	-
Dibromochloromethane	ppb	< 1	-	-	< 1	-	-	< 1	-
Dibromomethane	ppb	< 1	-	-	< 1	-	-	< 1	-
1,2-Dichlorobenzene	ppb	< 1	-	-	< 1	-	-	< 1	-
1,3-Dichlorobenzene	ppb	< 1	-	-	< 1	-	-	< 1	-
1,4-Dichlorobenzene	ppb	< 1	-	-	< 1	-	-	< 1	-
cis-1,4-Dichloro-2-butene	ppb	< 2	-	-	< 2	-	-	< 2	-
trans-1,4-Dichloro-2-butene	ppb	< 5	-	-	< 5	-	-	< 5	-
Dichlorodifluoromethane	ppb	< 1	-	-	< 1	-	-	< 1	-
1,1-Dichloroethane	ppb	< 1	-	-	< 1	-	-	< 1	-
1,2-Dichloroethane	ppb	< 1	-	-	< 1	-	-	< 1	-
1,1-Dichloroethene	ppb	< 1	-	-	< 1	-	-	< 1	-
trans-1,2-Dichloroethene	ppb	< 1	-	-	< 1	-	-	< 1	-
1,2-Dichloropropane	ppb	< 1	-	-	< 1	-	-	< 1	-
cis-1,3-Dichloropropene	ppb	< 1	-	-	< 1	-	-	< 1	-
trans-1,3-Dichloropropene	ppb	< 1	-	-	< 1	-	-	< 1	-
Ethanol	ppb	< 100	-	-	< 100	-	-	< 100	-
Ethylbenzene	ppb	< 1	-	-	2	-	-	< 1	-
Ethylene dibromide	ppb	< 1	-	-	< 1	-	-	< 1	-
Ethyl methacrylate	ppb	< 200	-	-	< 200	-	-	< 200	-
2-Hexanone	ppb	< 200	-	-	< 200	-	-	< 200	-
Iodomethane	ppb	< 1	-	-	< 1	-	-	< 1	-
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	-	< 200	-	-	< 200	-
Methylene chloride	ppb	< 1	-	-	< 1	-	-	< 1	-
Styrene	ppb	< 1	-	-	< 1	-	-	< 1	-
Tetrachloroethylene	ppb	< 1	-	-	< 1	-	-	< 1	-
1,1,2,2-Tetrachloroethane	ppb	< 5	-	-	< 5	-	-	< 5	-
Toluene	ppb	< 1	-	-	< 1	-	-	< 1	-
1,1,1-Trichloroethane	ppb	< 1	-	-	< 1	-	-	< 1	-
1,1,2-Trichloroethane	ppb	< 1	-	-	< 1	-	-	< 1	-
1,2,3-Trichloropropane	ppb	< 2	-	-	< 2	-	-	< 2	-
Trichloroethene	ppb	< 1	-	-	< 1	-	-	< 1	-
Trichlorofluoromethane	ppb	< 1	-	-	< 1	-	-	< 1	-
Vinyl acetate	ppb	< 100	-	-	< 100	-	-	< 100	-
Vinyl chloride	ppb	-	-	-	-	-	-	-	-
m+p-Xylenes	ppb	< 1	-	-	5	-	-	< 1	-
o-Xylene	ppb	< 1	-	-	2.7	-	-	< 1	-

*this value differs from that in the MRMP EIA, since the value in the EIA was calculated as the sum of maximum individual PAH concentrations

TID Seepage Attachment 1

- this data originated from sample site RW127, as described in Suncor's Lease 86 1995 reclamation program

Parameter	Units	11-Sep-95 data	min	median	max	count
Target PAHs and Alkylated PAHs		-				
Naphthalene	ppb	-	< 0.02	< 0.02	0.09	3
Methyl naphthalenes	ppb	-	< 0.02	< 0.02	0.05	3
C2 Subst'd naphthalenes	ppb	-	< 0.04	< 0.04	0.07	3
C3 Subst'd naphthalenes	ppb	-	< 0.04	< 0.04	0.27	3
C4 Subst'd naphthalenes	ppb	-	< 0.04	0.07	0.56	3
Acenaphthene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	-	< 0.04	< 0.04	0.28	3
Acenaphthylene	ppb	-	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	-	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	-	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	-	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/	ppb	-	< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		-	0	0	0	3
Benzo(a)pyrene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen	ppb	-	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluorar	ppb	-	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		-	0	0	0	3
Benzo(b&k)fluoranthene	ppb	-	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	-	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	-	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	-	< 0.04	< 0.04	< 0.04	3
C2 Subst'd biphenyl	ppb	-	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	-	< 0.04	< 0.04	0.05	3
C2 Subst'd dibenzothiophene	ppb	-	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	-	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	-	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	-	< 0.04	< 0.04	0.08	3
Fluorene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	-	< 0.04	< 0.04	0.26	3
C2 Subst'd fluorene	ppb	-	< 0.04	< 0.04	0.28	3
Indeno(c,d-123)pyrene	ppb	-	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracen	ppb	-	< 0.04	< 0.04	0.07	3
C2 Subst'd phenanthrene/anthra	ppb	-	< 0.04	0.06	0.06	3
C3 Subst'd phenanthrene/anthra	ppb	-	0.06	0.09	0.12	3
C4 Subst'd phenanthrene/anthra	ppb	-	< 0.04	< 0.04	0.06	3
1-Methyl-7-isopropyl-phenanth	ppb	-	< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	-	< 0.02		< 0.02	2
Total PAHs		-	0.33	0.36	1.89*	3
Target PANHs		-				
quinoline	ppb	-		< 0.02		1
7-Methyl quinoline	ppb	-	< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	-	< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	-	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	-	< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	-	< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	-	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	-	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	-	< 0.02	< 0.02	< 0.02	3
Phenolics		-				
Phenol	ppb	-		< 0.1		1
o-Cresol	ppb	< 1	< 1	< 0.2	< 0.1	3
m-Cresol	ppb	< 1	< 1	< 0.2	< 0.1	3
p-Cresol	ppb	< 1	< 1	< 0.2	< 0.1	3
2,4-Dimethylphenol	ppb	< 1	< 1	< 1	< 0.2	3
2-Nitrophenol	ppb	< 2	< 2	< 2	< 0.4	3

TID Seepage

- this data originated from sample site RW127, as described in Suncor's Lease 86 1995 reclamation program

Attachment 1

Parameter	Units	11-Sep-95 data	min	median	max	count
4-Nitrophenol	ppb	< 20	< 20	< 20	< 4	3
2,4-Dinitrophenol	ppb	< 20	< 20	< 20	< 4	3
4,6-Dinitro-2-methyl phenol	ppb	< 20	< 20	< 20	< 4	3
Volatile organics		-				
Acetone	ppb	-	< 100	< 100	< 100	3
Acrolein	ppb	-	< 100	< 100	< 100	3
Acrylonitrile	ppb	-	< 100	< 100	< 100	3
Benzene	ppb	-	< 1	< 1	< 1	3
Bromodichloromethane	ppb	-	< 1	< 1	< 1	3
Bromoform	ppb	-	< 1	< 1	< 1	3
Bromomethane	ppb	-	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	-	< 100	< 100	< 100	3
Carbon disulfide	ppb	-	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	-	< 1	< 1	< 1	3
Chlorobenzene	ppb	-	< 1	< 1	< 1	3
Chloroethane	ppb	-	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	-	< 5	< 5	< 5	3
Chloroform	ppb	-	< 1	< 1	< 1	3
Chloromethane	ppb	-	< 10	< 10	< 10	3
Dibromochloromethane	ppb	-	< 1	< 1	< 1	3
Dibromomethane	ppb	-	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	-	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	-	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	-	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	-	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	-	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	-	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	-	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	-	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	-	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	-	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	-	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	-	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	-	< 1	< 1	< 1	3
Ethanol	ppb	-	< 100	< 100	< 100	3
Ethylbenzene	ppb	-	< 1	< 1	1.5	3
Ethylene dibromide	ppb	-	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	-	< 200	< 200	< 200	3
2-Hexanone	ppb	-	< 200	< 200	< 200	3
Iodomethane	ppb	-	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	-	< 200	< 200	< 200	3
Methylene chloride	ppb	-	< 1	< 1	< 1	3
Styrene	ppb	-	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	-	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	-	< 5	< 5	< 5	3
Toluene	ppb	-	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	-	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	-	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	-	< 2	< 2	< 2	3
Trichloroethene	ppb	-	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	-	< 1	< 1	< 1	3
Vinyl acetate	ppb	-	< 100	< 100	< 100	3
Vinyl chloride	ppb	-				
m+p-Xylenes	ppb	-	< 1	< 1	5	3
o-Xylene	ppb	-	< 1	< 1	2.7	3

*this value differs from that in the MRMP EIA, since the value in the EIA was calculated as the sum of maximum individual PAH concentrations

Suncor Wastewater

- this data originated from sample site RW254, as described in Suncor's Lease 86 1995 reclamation program

Attachment 1

Parameter	Units	14-Jul-95 data	- data	25-Jul-95 data	min	median	max	count
Target PAHs and Alkylated PAHs		-	-	-				
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	0.05	0.1	0.04	0.04	0.05	0.1	3
C2 Subst'd naphthalenes	ppb	< 0.04	0.04	0.14	< 0.04	0.04	0.14	3
C3 Subst'd naphthalenes	ppb	< 0.04	0.34	0.09	< 0.04	0.09	0.34	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.02	< 0.04	< 0.04	< 0.02	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.04	< 0.04	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.02	< 0.04	< 0.04	< 0.02	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	0.04	0.05	< 0.04	< 0.04	0.04	0.05	3
Methyl benzo(a)anthracene/chrys	ppb	0.12	0.07	< 0.04	< 0.04	0.07	0.12	3
C2 Subst'd benzo(a)anthracene/c	ppb	0.12	< 0.04	< 0.02	< 0.04	< 0.02	0.12	3
Benzo(a)anthracene grp		0.28	0.12	0	0	0.12	0.28	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.04	< 0.04	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthene	ppb	0.06	0.07	< 0.04	< 0.04	0.06	0.07	3
C2 Subst'd benzo(b& k) fluorant	ppb	0.07	< 0.04	< 0.02	< 0.04	< 0.02	0.07	3
Benzo(a)pyrene grp		0.13	0.07	0	0	0.07	0.13	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	0.03	< 0.02	< 0.04	< 0.04	< 0.02	0.03	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	3
C2 Subst'd biphenyl	ppb	< 0.04	< 0.04	0.06	< 0.04	< 0.04	0.06	3
Dibenzothiophene	ppb	0.09	< 0.02	0.12	< 0.02	0.09	0.12	3
Methyl dibenzothiophene	ppb	0.21	< 0.04	0.19	< 0.04	0.19	0.21	3
C2 Subst'd dibenzothiophene	ppb	0.07	< 0.04	0.12	< 0.04	0.07	0.12	3
C3 Subst'd dibenzothiophene	ppb	0.11	< 0.04	< 0.04	< 0.04	< 0.04	0.11	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.02	< 0.04	< 0.04	< 0.02	3
Fluoranthene	ppb	< 0.02	< 0.02	0.27	< 0.02	< 0.02	0.27	3
Methyl fluoranthene/pyrene	ppb	< 0.04	0.31	< 0.02	< 0.04	< 0.02	0.31	3
Fluorene	ppb	< 0.02	< 0.02	< 0.04	< 0.04	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	0.16	< 0.04	< 0.04	0.16	3
C2 Subst'd fluorene	ppb	< 0.04	< 0.04	< 0.02	< 0.04	< 0.04	< 0.02	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	0.19	< 0.02	< 0.02	0.19	3
Methyl phenanthrene/anthracene	ppb	< 0.04	0.19	0.16	< 0.04	0.16	0.19	3
C2 Subst'd phenanthrene/anthrac	ppb	< 0.04	0.22	0.16	< 0.04	0.16	0.22	3
C3 Subst'd phenanthrene/anthrac	ppb	< 0.04	0.25	0.09	< 0.04	0.09	0.25	3
C4 Subst'd phenanthrene/anthrac	ppb	< 0.04	0.33	-	< 0.04		0.33	2
1-Methyl-7-isopropyl-phenanthre	ppb	< 0.04	< 0.04	-	< 0.04		< 0.04	2
Pyrene	ppb	0.16	< 0.02	-	< 0.02		0.16	2
Total PAHs		1.13	1.97	1.79	1.13	1.79	1.97*	3
Target PANHs			-	-				
quinoline	ppb	< 0.02	-	-		< 0.02		1
7-Methyl quinoline	ppb	0.46	0.12	0.31	0.12	0.31	0.46	3
C2 Subst'd quinoline	ppb	0.09	0.18	0.4	0.09	0.18	0.4	3
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	0.13	< 0.02	< 0.02	< 0.02	< 0.02	0.13	3
Methyl acridine	ppb	< 0.02	< 0.02	0.6	< 0.02	< 0.02	0.6	3
Phenanthridine	ppb	< 0.02	0.21	< 0.02	< 0.02	< 0.02	0.21	3
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	3
Phenolics		-	-	-				
Phenol	ppb	< 0.1	-	-		< 0.1		1
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	3
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	3
4-Nitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
Volatile organics		-	-	-				

Suncor Wastewater
- this data originated from sample site RW254, as described in Suncor's Lease 86 1995 reclamation program

Attachment 1

		14-Jul-95	-	25-Jul-95				
Parameter	**Units**	**data**	**data**	**data**	**min**	**median**	**max**	**count**
Acetone	ppb	< 100	< 100	< 100	< 100	< 100	< 100	3
Acrolein	ppb	< 100	< 100	< 100	< 100	< 100	< 100	3
Acrylonitrile	ppb	< 100	< 100	< 100	< 100	< 100	< 100	3
Benzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Bromodichloromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Bromoform	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Bromomethane	ppb	< 10	< 10	< 10	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	< 100	< 100	< 100	< 100	< 100	< 100	3
Carbon disulfide	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Chlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Chloroethane	ppb	< 10	< 10	< 10	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	< 5	< 5	< 5	< 5	< 5	< 5	3
Chloroform	ppb	< 1	1.3	< 1	< 1	< 1	1.3	3
Chloromethane	ppb	< 10	< 10	< 10	< 10	< 10	< 10	3
Dibromochloromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Dibromomethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	< 5	< 5	< 5	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Ethanol	ppb	< 100	< 100	< 100	< 100	< 100	< 100	3
Ethylbenzene	ppb	< 1	1.2	< 1	< 1	< 1	1.2	3
Ethylene dibromide	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	< 200	< 200	< 200	< 200	< 200	< 200	3
2-Hexanone	ppb	< 200	< 200	< 200	< 200	< 200	< 200	3
Iodomethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	< 200	< 200	< 200	< 200	< 200	< 200	3
Methylene chloride	ppb	< 1	< 1	5.7	< 1	< 1	5.7	3
Styrene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	< 5	< 5	< 5	< 5	< 5	< 5	3
Toluene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	< 2	< 2	< 2	< 2	< 2	< 2	3
Trichloroethene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	3
Vinyl acetate	ppb	< 100	< 100	< 100	< 100	< 100	< 100	3
Vinyl chloride	ppb	-	-	-				
m+p-Xylenes	ppb	< 1	4.5	< 1	< 1	< 1	4.5	3
o-Xylene	ppb	< 1	2.2	< 1	< 1	< 1	2.2	3

*this value differs from that in the MRMP EIA, since the value in the EIA was calculated as the sum of maximum individual PAH concentrations

Cooling Pond Water **Attachment 1**

- data originated from sample site RW256, as described in Suncor's Lease 86 1995 reclamation program and from Naquadata database

Parameter	Units	14-Jul-95 data	27-Jul-95 data	31-Jul-95 data	9-Aug-95 data	18-Aug-95 data	20-Aug-95 data	10-Sep-95 data	11-Sep-95 data
Target PAHs and Alkylated PAHs		-	-	-	-	-	-	-	-
Naphthalene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl naphthalenes	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
C2 Subst'd naphthalenes	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C3 Subst'd naphthalenes	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C4 Subst'd naphthalenes	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Acenaphthene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl acenaphthene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Acenaphthylene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Anthracene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Dibenzo(a,h)anthracene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Benzo(a)Anthracene/Chrysene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl benzo(a)anthracene/chr	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C2 Subst'd benzo(a)anthracene/	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Benzo(a)anthracene grp		-	0	-	-	-	0	0	-
Benzo(a)pyrene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl benzo(b&k) fluoranthen	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C2 Subst'd benzo(b& k) fluorar	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Benzo(a)pyrene grp		-	0	-	-	-	0	0	-
Benzo(b&k)fluoranthene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Benzo(g,h,i)perylene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Biphenyl	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Methyl biphenyl	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C2 Subst'd biphenyl	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Dibenzothiophene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C2 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C3 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C4 Subst'd dibenzothiophene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Fluoranthene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl fluoranthene/pyrene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Fluorene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl fluorene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C2 Subst'd fluorene	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Indeno(c,d-123)pyrene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Phenanthrene	ppb	-	< 0.02	-	-	-	< 0.02	< 0.02	-
Methyl phenanthrene/anthracen	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C2 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C3 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
C4 Subst'd phenanthrene/anthra	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
1-Methyl-7-isopropyl-phenanthı	ppb	-	< 0.04	-	-	-	< 0.04	< 0.04	-
Pyrene	ppb	-	-	-	-	-	< 0.02	< 0.02	-
Total PAHs		-	0	-	-	-	0	0	-
Target PANHs		-	-	-	-	-	-	-	-
quinoline	ppb	-	-	< 0.02	-	-	-	-	-
7-Methyl quinoline	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
C2 Subst'd quinoline	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
C3 Subst'd quinoline	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
Acridine	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
Methyl acridine	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
Phenanthridine	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
Carbazole	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
Methyl carbazole	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
C2 Subst'd carbazole	ppb	-	-	< 0.02	-	-	< 0.02	< 0.02	-
Phenolics		-	-	-	-	-	-	-	-
Phenol	ppb	-	< 0.1	-	-	-	-	-	< 0.1
o-Cresol	ppb	-	< 0.1	-	-	< 0.1	-	-	< 0.1
m-Cresol	ppb	-	< 0.1	-	-	< 0.1	-	-	< 0.1
p-Cresol	ppb	-	< 0.1	-	-	< 0.1	-	-	< 0.1
2,4-Dimethylphenol	ppb	-	< 0.1	-	-	< 0.1	-	-	< 0.1
2-Nitrophenol	ppb	-	< 0.2	-	-	< 0.2	-	-	< 0.2
4-Nitrophenol	ppb	-	< 2	-	-	< 2	-	-	< 2

Cooling Pond Water Attachment 1

- data originated from sample site RW256, as described in Suncor's Lease 86 1995 reclamation program and from Naquadata database

Parameter	Units	14-Jul-95 data	27-Jul-95 data	31-Jul-95 data	9-Aug-95 data	18-Aug-95 data	20-Aug-95 data	10-Sep-95 data	11-Sep-95 data
Target PAHs and Alkylated PAHs		-	-	-	-	-	-	-	-
2,4-Dinitrophenol	ppb	-	< 2	-	-	< 2	-	-	< 2
4,6-Dinitro-2-methyl phenol	ppb	-	< 2	-	-	< 2	-	-	< 2
Volatile organics		-	-	-	-	-	-	-	-
Acetone	ppb	< 100	-	-	< 100	-	-	-	< 100
Acrolein	ppb	< 100	-	-	< 100	-	-	-	< 100
Acrylonitrile	ppb	< 100	-	-	< 100	-	-	-	< 100
Benzene	ppb	< 1	-	-	< 1	-	-	-	< 1
Bromodichloromethane	ppb	< 1	-	-	< 1	-	-	-	< 1
Bromoform	ppb	< 1	-	-	< 1	-	-	-	< 1
Bromomethane	ppb	< 10	-	-	< 10	-	-	-	< 10
2-Butanone (MEK)	ppb	< 100	-	-	< 100	-	-	-	< 100
Carbon disulfide	ppb	< 1	-	-	< 1	-	-	-	< 1
Carbon tetrachloride	ppb	< 1	-	-	< 1	-	-	-	< 1
Chlorobenzene	ppb	< 1	-	-	< 1	-	-	-	< 1
Chloroethane	ppb	< 10	-	-	< 10	-	-	-	< 10
2-Chloroethyl vinyl ether	ppb	< 5	-	-	< 5	-	-	-	< 5
Chloroform	ppb	< 1	-	-	< 1	-	-	-	< 1
Chloromethane	ppb	< 10	-	-	< 10	-	-	-	< 10
Dibromochloromethane	ppb	< 1	-	-	< 1	-	-	-	< 1
Dibromomethane	ppb	< 1	-	-	< 1	-	-	-	< 1
1,2-Dichlorobenzene	ppb	< 1	-	-	< 1	-	-	-	< 1
1,3-Dichlorobenzene	ppb	< 1	-	-	< 1	-	-	-	< 1
1,4-Dichlorobenzene	ppb	< 1	-	-	< 1	-	-	-	< 1
cis-1,4-Dichloro-2-butene	ppb	< 2	-	-	< 2	-	-	-	< 2
trans-1,4-Dichloro-2-butene	ppb	< 5	-	-	< 5	-	-	-	< 5
Dichlorodifluoromethane	ppb	< 1	-	-	< 1	-	-	-	< 1
1,1-Dichloroethane	ppb	< 1	-	-	< 1	-	-	-	< 1
1,2-Dichloroethane	ppb	< 1	-	-	< 1	-	-	-	< 1
1,1-Dichloroethene	ppb	< 1	-	-	< 1	-	-	-	< 1
trans-1,2-Dichloroethene	ppb	< 1	-	-	< 1	-	-	-	< 1
1,2-Dichloropropane	ppb	< 1	-	-	< 1	-	-	-	< 1
cis-1,3-Dichloropropene	ppb	< 1	-	-	< 1	-	-	-	< 1
trans-1,3-Dichloropropene	ppb	< 1	-	-	< 1	-	-	-	< 1
Ethanol	ppb	< 100	-	-	< 100	-	-	-	< 100
Ethylbenzene	ppb	< 1	-	-	2	-	-	-	< 1
Ethylene dibromide	ppb	< 1	-	-	< 1	-	-	-	< 1
Ethyl methacrylate	ppb	< 200	-	-	< 200	-	-	-	< 200
2-Hexanone	ppb	< 200	-	-	< 200	-	-	-	< 200
Iodomethane	ppb	< 1	-	-	< 1	-	-	-	< 1
4-Methyl-2-pentanone (MIBK)	ppb	< 200	-	-	< 200	-	-	-	< 200
Methylene chloride	ppb	< 1	-	-	< 1	-	-	-	< 1
Styrene	ppb	< 1	-	-	< 1	-	-	-	< 1
Tetrachloroethylene	ppb	< 1	-	-	< 1	-	-	-	< 1
1,1,2,2-Tetrachloroethane	ppb	< 5	-	-	< 5	-	-	-	< 5
Toluene	ppb	< 1	-	-	< 1	-	-	-	< 1
1,1,1-Trichloroethane	ppb	< 1	-	-	< 1	-	-	-	< 1
1,1,2-Trichloroethane	ppb	< 1	-	-	< 1	-	-	-	< 1
1,2,3-Trichloropropane	ppb	< 2	-	-	< 2	-	-	-	< 2
Trichloroethene	ppb	< 1	-	-	< 1	-	-	-	< 1
Trichlorofluoromethane	ppb	< 1	-	-	< 1	-	-	-	< 1
Vinyl acetate	ppb	< 100	-	-	< 100	-	-	-	< 100
Vinyl chloride	ppb	-	-	-	-	-	-	-	-
m+p-Xylenes	ppb	< 1	-	-	5.7	-	-	-	< 1
o-Xylene	ppb	< 1	-	-	2.8	-	-	-	< 1

Cooling Pond Water **Attachment 1**

- data originated from sample site RW256, as described in Suncor's Lease 86 1995 reclamation program and from Naquadata database

Parameter	Units	min	median	max	count
Target PAHs and Alkylated PAHs					
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl naphthalenes	ppb	< 0.02	< 0.02	< 0.02	3
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	3
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	3
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	3
Acenaphthylene	ppb	< 0.02	< 0.02	< 0.02	3
Anthracene	ppb	< 0.02	< 0.02	< 0.02	3
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	3
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	< 0.04	3
Benzo(a)anthracene grp		0	0	0	3
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04	3
C2 Subst'd benzo(b& k) fluorar	ppb	< 0.04	< 0.04	< 0.04	3
Benzo(a)pyrene grp		0	0	0	3
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	3
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	3
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	3
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	3
C2 Subst'd biphenyl	ppb	< 0.04	< 0.04	< 0.04	3
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	3
C2 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	3
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	3
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	3
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	3
Fluorene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	3
C2 Subst'd fluorene	ppb	< 0.04	< 0.04	< 0.04	3
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	3
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	3
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04	< 0.04	3
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	3
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	3
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	3
1-Methyl-7-isopropyl-phenanthi	ppb	< 0.04	< 0.04	< 0.04	3
Pyrene	ppb	< 0.02	< 0.02	< 0.02	2
Total PAHs		0	0	0	3
Target PANHs					
quinoline	ppb	< 0.02	< 0.02	< 0.02	1
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	3
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	3
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	3
Acridine	ppb	< 0.02	< 0.02	< 0.02	3
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	3
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	3
Carbazole	ppb	< 0.02	< 0.02	< 0.02	3
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	3
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	3
Phenolics					
Phenol	ppb	< 0.1	< 0.1	< 0.1	2
o-Cresol	ppb	< 0.1	< 0.1	< 0.1	3
m-Cresol	ppb	< 0.1	< 0.1	< 0.1	3
p-Cresol	ppb	< 0.1	< 0.1	< 0.1	3
2,4-Dimethylphenol	ppb	< 0.1	< 0.1	< 0.1	3
2-Nitrophenol	ppb	< 0.2	< 0.2	< 0.2	3
4-Nitrophenol	ppb	< 2	< 2	< 2	3

Cooling Pond Water

- data originated from sample site RW256, as described in Suncor's Lease 86 1995 reclamation program and from Naquadata database

Attachment 1

Parameter	Units	min	median	max	count
Target PAHs and Alkylated PAHs					
2,4-Dinitrophenol	ppb	< 2	< 2	< 2	3
4,6-Dinitro-2-methyl phenol	ppb	< 2	< 2	< 2	3
Volatile organics					
Acetone	ppb	< 100	< 100	< 100	3
Acrolein	ppb	< 100	< 100	< 100	3
Acrylonitrile	ppb	< 100	< 100	< 100	3
Benzene	ppb	< 1	< 1	< 1	3
Bromodichloromethane	ppb	< 1	< 1	< 1	3
Bromoform	ppb	< 1	< 1	< 1	3
Bromomethane	ppb	< 10	< 10	< 10	3
2-Butanone (MEK)	ppb	< 100	< 100	< 100	3
Carbon disulfide	ppb	< 1	< 1	< 1	3
Carbon tetrachloride	ppb	< 1	< 1	< 1	3
Chlorobenzene	ppb	< 1	< 1	< 1	3
Chloroethane	ppb	< 10	< 10	< 10	3
2-Chloroethyl vinyl ether	ppb	< 5	< 5	< 5	3
Chloroform	ppb	< 1	< 1	< 1	3
Chloromethane	ppb	< 10	< 10	< 10	3
Dibromochloromethane	ppb	< 1	< 1	< 1	3
Dibromomethane	ppb	< 1	< 1	< 1	3
1,2-Dichlorobenzene	ppb	< 1	< 1	< 1	3
1,3-Dichlorobenzene	ppb	< 1	< 1	< 1	3
1,4-Dichlorobenzene	ppb	< 1	< 1	< 1	3
cis-1,4-Dichloro-2-butene	ppb	< 2	< 2	< 2	3
trans-1,4-Dichloro-2-butene	ppb	< 5	< 5	< 5	3
Dichlorodifluoromethane	ppb	< 1	< 1	< 1	3
1,1-Dichloroethane	ppb	< 1	< 1	< 1	3
1,2-Dichloroethane	ppb	< 1	< 1	< 1	3
1,1-Dichloroethene	ppb	< 1	< 1	< 1	3
trans-1,2-Dichloroethene	ppb	< 1	< 1	< 1	3
1,2-Dichloropropane	ppb	< 1	< 1	< 1	3
cis-1,3-Dichloropropene	ppb	< 1	< 1	< 1	3
trans-1,3-Dichloropropene	ppb	< 1	< 1	< 1	3
Ethanol	ppb	< 100	< 100	< 100	3
Ethylbenzene	ppb	< 1	< 1	1.5	3
Ethylene dibromide	ppb	< 1	< 1	< 1	3
Ethyl methacrylate	ppb	< 200	< 200	< 200	3
2-Hexanone	ppb	< 200	< 200	< 200	3
Iodomethane	ppb	< 1	< 1	< 1	3
4-Methyl-2-pentanone (MIBK)	ppb	< 200	< 200	< 200	3
Methylene chloride	ppb	< 1	< 1	< 1	3
Styrene	ppb	< 1	< 1	< 1	3
Tetrachloroethylene	ppb	< 1	< 1	< 1	3
1,1,2,2-Tetrachloroethane	ppb	< 5	< 5	< 5	3
Toluene	ppb	< 1	< 1	< 1	3
1,1,1-Trichloroethane	ppb	< 1	< 1	< 1	3
1,1,2-Trichloroethane	ppb	< 1	< 1	< 1	3
1,2,3-Trichloropropane	ppb	< 2	< 2	< 2	3
Trichloroethene	ppb	< 1	< 1	< 1	3
Trichlorofluoromethane	ppb	< 1	< 1	< 1	3
Vinyl acetate	ppb	< 100	< 100	< 100	3
Vinyl chloride	ppb	-	-	-	-
m+p-Xylenes	ppb	< 1	< 1	5.7	3
o-Xylene	ppb	< 1	< 1	2.8	3

Parameter	Units	Suncor's Lease 86 1995 reclamation program RW162 data	RW162 data	RW162 data	RW163 data	RW163 data	RW164 data	Syncrude Flume deposit 1-May-95 data	Suncor Pond 5 12-Dec-95 data
Target PAHs and Alkylated PAHs									
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.05
Methyl naphthalenes	ppb	0.05	< 0.02	0.04	< 0.02	0.05	< 0.02	< 0.02	0.06
C2 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.11
C3 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.3
C4 Subst'd naphthalenes	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.56
Acenaphthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.16
Methyl acenaphthene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.19
Acenaphthylene	ppb	0.08	< 0.02	0.06	< 0.02	0.07	< 0.02	< 0.02	< 0.02
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Benzo(a)Anthracene/Chrysene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl benzo(a)anthracene/chry	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.06
C2 Subst'd benzo(a)anthracene/	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.1
Benzo(a)anthracene grp		0	0	0	0	0	0	0	0.16
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl benzo(b&k) fluoranthen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd benzo(b& k) fluoran	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Benzo(a)pyrene grp		0	0	0	0	0	0	0	0
Benzo(b&k)fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Biphenyl	ppb	0.08	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Methyl biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Dibenzothiophene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.39
C3 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.85
C4 Subst'd dibenzothiophene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.58
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl fluoranthene/pyrene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.09
Fluorene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd fluorene	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.14
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenanthrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl phenanthrene/anthracen	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.23
C3 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.44
C4 Subst'd phenanthrene/anthra	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.38
1-Methyl-7-isopropyl-phenanthı	ppb	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	-	< 0.04
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.04
Total PAHs		0.21	0	0.1	0	0.12	0	0	4.73
Target PANHs									
quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
7-Methyl quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C2 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C3 Subst'd quinoline	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl acridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenanthridine	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Methyl carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C2 Subst'd carbazole	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenolics									
Phenol	ppb	< 0.4	0.1	< 0.4	< 1	< 0.4	0.2	-	< 0.02
o-Cresol	ppb	< 0.4	0.3	< 0.4	< 1	< 0.4	< 0.1	-	< 0.02
m-Cresol	ppb	< 0.4	< 0.1	< 0.4	< 1	< 0.4	0.3	-	0.5
p-Cresol	ppb	< 0.4	< 0.1	< 0.4	< 1	< 0.4	< 0.1	-	< 0.02
2,4-Dimethylphenol	ppb	< 0.4	< 1	< 0.4	< 1	< 0.4	0.2	-	1
2-Nitrophenol	ppb	< 2	< 2	< 2	< 2	< 2	< 2	-	< 0.4
4-Nitrophenol	ppb	< 20	< 20	< 20	< 20	< 20	< 20	-	< 4

		Suncor's Lease 86 1995 reclamation program						Syncrude	Suncor
								Flume deposit	Pond 5
		RW162	RW162	RW162	RW163	RW163	RW164	1-May-95	12-Dec-95
Parameter	**Units**	**data**	**data**	**data**	**data**	**data**	**data**	**data**	**data**
2,4-Dinitrophenol	ppb	< 20	< 20	< 20	< 20	< 20	< 20	-	< 4
4,6-Dinitro-2-methyl phenol	ppb	< 20	< 20	< 20	< 20	< 20	< 20	-	< 4
Volatile organics									
Acetone	ppb	< 100	< 100	< 100	< 100	< 100	< 100	-	< 1500
Acrolein	ppb	< 100	< 100	< 100	< 100	< 100	< 100	-	< 1500
Acrylonitrile	ppb	< 100	< 100	< 100	< 100	< 100	< 100	-	< 1500
Benzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Bromodichloromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Bromoform	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Bromomethane	ppb	< 10	< 10	< 10	< 10	< 10	< 10	-	< 150
2-Butanone (MEK)	ppb	< 100	< 100	< 100	< 100	< 100	< 100	-	< 1500
Carbon disulfide	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Carbon tetrachloride	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Chlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Chloroethane	ppb	< 10	< 10	< 10	< 10	< 10	< 10	-	< 150
2-Chloroethyl vinyl ether	ppb	< 5	< 5	< 5	< 5	< 5	< 5	-	< 75
Chloroform	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Chloromethane	ppb	< 10	< 10	< 10	< 10	< 10	< 10	-	< 150
Dibromochloromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Dibromomethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,2-Dichlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,3-Dichlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,4-Dichlorobenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
cis-1,4-Dichloro-2-butene	ppb	< 2	< 2	< 2	< 2	< 2	< 2	-	< 30
trans-1,4-Dichloro-2-butene	ppb	< 5	< 5	< 5	< 5	< 5	< 5	-	< 75
Dichlorodifluoromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,1-Dichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,2-Dichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,1-Dichloroethene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
trans-1,2-Dichloroethene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,2-Dichloropropane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
cis-1,3-Dichloropropene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
trans-1,3-Dichloropropene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Ethanol	ppb	< 100	< 100	< 100	< 100	< 100	< 100	-	< 1500
Ethylbenzene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Ethylene dibromide	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Ethyl methacrylate	ppb	< 200	< 200	< 200	< 200	< 200	< 200	-	< 3000
2-Hexanone	ppb	< 200	< 200	< 200	< 200	< 200	< 200	-	< 3000
Iodomethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
4-Methyl-2-pentanone (MIBK)	ppb	< 200	< 200	< 200	< 200	< 200	< 200	-	< 3000
Methylene chloride	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Styrene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Tetrachloroethylene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,1,2,2-Tetrachloroethane	ppb	< 5	< 5	< 5	< 5	< 5	< 5	-	< 75
Toluene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,1,1-Trichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,1,2-Trichloroethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
1,2,3-Trichloropropane	ppb	< 2	< 2	< 2	< 2	< 2	< 2	-	< 30
Trichloroethene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Trichlorofluoromethane	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	< 15
Vinyl acetate	ppb	< 100	< 100	< 100	< 100	< 100	< 100	-	< 1500
Vinyl chloride	ppb	< 20	< 20	< 20	< 20	< 20	< 20	-	< 300
m+p-Xylenes	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	15
o-Xylene	ppb	< 1	< 1	< 1	< 1	< 1	< 1	-	15

*this value is smaller that the one listed in Table V-2, Section E-5 of the MRMP EIA, since
1) the value in the EIA was calculated as the sum of maximum individual PAH concentrations
2) the values for the benzo(a)anthracene and benzo(a)pyrene groups were accidently included this sumation.

Parameter	Units	Suncor CT1219 5-Jan-96 data	Suncor Pond 5 surface 21-Aug-96 data	min	median	max	count
Target PAHs and Alkylated PAHs							
Naphthalene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	0.05	10
Methyl naphthalenes	ppb	0.08	0.03	< 0.02	0.035	0.08	10
C2 Subst'd naphthalenes	ppb	0.25	0.11	< 0.04	< 0.04	0.25	10
C3 Subst'd naphthalenes	ppb	0.07	0.1	< 0.04	< 0.04	0.3	10
C4 Subst'd naphthalenes	ppb	2	0.19	< 0.04	< 0.04	2	10
Acenaphthene	ppb	< 0.02	0.07	< 0.02	< 0.02	0.16	10
Methyl acenaphthene	ppb	0.17	0.11	< 0.04	< 0.04	0.19	10
Acenaphthylene	ppb	< 0.02	0.02	< 0.02	< 0.02	0.08	10
Anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Dibenzo(a,h)anthracene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Benzo(a)Anthracene/Chrysene	ppb	0.27	< 0.02	< 0.02	< 0.02	0.27	10
Methyl benzo(a)anthracene/chry	ppb	0.5	< 0.04	< 0.04	< 0.04	0.5	10
C2 Subst'd benzo(a)anthracene/	ppb	0.83	< 0.04	< 0.04	< 0.04	0.83	10
Benzo(a)anthracene grp		1.6	0	0	0	1.6	10
Benzo(a)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Methyl benzo(b&k) fluoranthen	ppb	0.3	< 0.02	< 0.04	< 0.04	0.3	10
C2 Subst'd benzo(b& k) fluoran	ppb	0.18	< 0.04	< 0.04	< 0.04	0.18	10
Benzo(a)pyrene grp		0.48	0	0	0	0.48	10
Benzo(b&k)fluoranthene	ppb	< 0.02	-	< 0.02	< 0.02	< 0.02	9
Benzo(g,h,i)perylene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Biphenyl	ppb	< 0.04	< 0.04	< 0.04	< 0.04	0.08	10
Methyl biphenyl	ppb	< 0.04	0.09	< 0.04	< 0.04	0.09	10
C2 Subst'd biphenyl	ppb	0.25	0.07	< 0.04	< 0.04	0.25	10
Dibenzothiophene	ppb	0.07	< 0.02	< 0.02	< 0.02	0.07	10
Methyl dibenzothiophene	ppb	0.65	0.05	< 0.04	< 0.04	0.65	10
C2 Subst'd dibenzothiophene	ppb	2.2	0.17	< 0.04	< 0.04	2.2	10
C3 Subst'd dibenzothiophene	ppb	4.1	0.2	< 0.04	< 0.04	4.1	10
C4 Subst'd dibenzothiophene	ppb	4.4	0.32	< 0.04	< 0.04	4.4	10
Fluoranthene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Methyl fluoranthene/pyrene	ppb	0.65	0.06	< 0.04	< 0.04	0.65	10
Fluorene	ppb	0.03	< 0.02	< 0.02	< 0.02	0.03	10
Methyl fluorene	ppb	0.3	0.07	< 0.04	< 0.04	0.3	10
C2 Subst'd fluorene	ppb	1.1	0.5	< 0.04	< 0.04	1.1	10
Indeno(c,d-123)pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	10
Phenanthrene	ppb	0.09	< 0.02	< 0.02	< 0.02	0.09	10
Methyl phenanthrene/anthracen	ppb	0.79	< 0.04	< 0.04	< 0.04	0.79	10
C2 Subst'd phenanthrene/anthra	ppb	4.5	0.05	< 0.04	< 0.04	4.5	10
C3 Subst'd phenanthrene/anthra	ppb	3.6	0.04	< 0.04	< 0.04	3.6	10
C4 Subst'd phenanthrene/anthra	ppb	1.7	0.04	< 0.04	< 0.04	1.7	10
1-Methyl-7-isopropyl-phenanthi	ppb	< 0.04	-	< 0.04	< 0.04	< 0.04	8
Pyrene	ppb	< 0.02	< 0.02	< 0.02	< 0.02	0.04	10
Total PAHs		29.08	2.2	0	0.11	29.08*	10
Target PANHs							
quinoline	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
7-Methyl quinoline	ppb	< 0.02	0.16	< 0.02	< 0.02	0.16	10
C2 Subst'd quinoline	ppb	< 0.02	0.14	< 0.02	< 0.02	0.14	10
C3 Subst'd quinoline	ppb	< 0.02	0.17	< 0.02	< 0.02	0.17	10
Acridine	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
Methyl acridine	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
Phenanthridine	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
Carbazole	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
Methyl carbazole	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
C2 Subst'd carbazole	ppb	< 0.02	< 0.03	< 0.03	< 0.02	< 0.02	10
Phenolics							
Phenol	ppb	0.2	-	< 1	< 0.21	0.2	8
o-Cresol	ppb	< 0.5	-	< 1	< 0.4	0.3	8
m-Cresol	ppb	< 1	-	< 1	< 0.4	0.5	8
p-Cresol	ppb	< 0.5	-	< 1	< 0.4	< 0.02	8
2,4-Dimethylphenol	ppb	0.5	-	< 1	< 0.4	1	8
2-Nitrophenol	ppb	< 2	-	< 2	< 2	< 0.4	8
4-Nitrophenol	ppb	< 20	-	< 20	< 20	< 4	8

		Suncor	Suncor Pond 5				
		CT1219	surface				
		5-Jan-96	21-Aug-96				
Parameter	**Units**	**data**	**data**	**min**	**median**	**max**	**count**
2,4-Dinitrophenol	ppb	< 20	-	< 20	< 20	< 4	8
4,6-Dinitro-2-methyl phenol	ppb	< 20	-	< 20	< 20	< 4	8
Volatile organics							
Acetone	ppb	< 1500	-	< 1500	< 100	< 100	8
Acrolein	ppb	< 1500	-	< 1500	< 100	< 100	8
Acrylonitrile	ppb	< 1500	-	< 1500	< 100	< 100	8
Benzene	ppb	< 15	-	< 15	< 1	< 1	8
Bromodichloromethane	ppb	< 15	-	< 15	< 1	< 1	8
Bromoform	ppb	< 15	-	< 15	< 1	< 1	8
Bromomethane	ppb	< 150	-	< 150	< 10	< 10	8
2-Butanone (MEK)	ppb	< 1500	-	< 1500	< 100	< 100	8
Carbon disulfide	ppb	< 15	-	< 15	< 1	< 1	8
Carbon tetrachloride	ppb	< 15	-	< 15	< 1	< 1	8
Chlorobenzene	ppb	< 15	-	< 15	< 1	< 1	8
Chloroethane	ppb	< 150	-	< 150	< 10	< 10	8
2-Chloroethyl vinyl ether	ppb	< 75	-	< 75	< 5	< 5	8
Chloroform	ppb	< 15	-	< 15	< 1	< 1	8
Chloromethane	ppb	< 150	-	< 150	< 10	< 10	8
Dibromochloromethane	ppb	< 15	-	< 15	< 1	< 1	8
Dibromomethane	ppb	< 15	-	< 15	< 1	< 1	8
1,2-Dichlorobenzene	ppb	< 15	-	< 15	< 1	< 1	8
1,3-Dichlorobenzene	ppb	< 15	-	< 15	< 1	< 1	8
1,4-Dichlorobenzene	ppb	< 15	-	< 15	< 1	< 1	8
cis-1,4-Dichloro-2-butene	ppb	< 30	-	< 30	< 2	< 2	8
trans-1,4-Dichloro-2-butene	ppb	< 75	-	< 75	< 5	< 5	8
Dichlorodifluoromethane	ppb	< 15	-	< 15	< 1	< 1	8
1,1-Dichloroethane	ppb	< 15	-	< 15	< 1	< 1	8
1,2-Dichloroethane	ppb	< 15	-	< 15	< 1	< 1	8
1,1-Dichloroethene	ppb	< 15	-	< 15	< 1	< 1	8
trans-1,2-Dichloroethene	ppb	< 15	-	< 15	< 1	< 1	8
1,2-Dichloropropane	ppb	< 15	-	< 15	< 1	< 1	8
cis-1,3-Dichloropropene	ppb	< 15	-	< 15	< 1	< 1	8
trans-1,3-Dichloropropene	ppb	< 15	-	< 15	< 1	< 1	8
Ethanol	ppb	< 1500	-	< 1500	< 100	< 100	8
Ethylbenzene	ppb	< 15	-	< 15	< 1	< 1	8
Ethylene dibromide	ppb	< 15	-	< 15	< 1	< 1	8
Ethyl methacrylate	ppb	< 3000	-	< 3000	< 200	< 200	8
2-Hexanone	ppb	< 3000	-	< 3000	< 200	< 200	8
Iodomethane	ppb	< 15	-	< 15	< 1	< 1	8
4-Methyl-2-pentanone (MIBK)	ppb	< 3000	-	< 3000	< 200	< 200	8
Methylene chloride	ppb	< 15	-	< 15	< 1	< 1	8
Styrene	ppb	< 15	-	< 15	< 1	< 1	8
Tetrachloroethylene	ppb	< 15	-	< 15	< 1	< 1	8
1,1,2,2-Tetrachloroethane	ppb	< 75	-	< 75	< 5	< 5	8
Toluene	ppb	< 15	-	< 15	< 1	< 1	8
1,1,1-Trichloroethane	ppb	< 15	-	< 15	< 1	< 1	8
1,1,2-Trichloroethane	ppb	< 15	-	< 15	< 1	< 1	8
1,2,3-Trichloropropane	ppb	< 30	-	< 30	< 2	< 2	8
Trichloroethene	ppb	< 15	-	< 15	< 1	< 1	8
Trichlorofluoromethane	ppb	< 15	-	< 15	< 1	< 1	8
Vinyl acetate	ppb	< 1500	-	< 1500	< 100	< 100	8
Vinyl chloride	ppb	< 300	-	< 300	< 20	< 20	8
m+p-Xylenes	ppb	< 15	-	< 15	< 1	15	8
o-Xylene	ppb	< 15	-	< 15	< 1	15	8

*this value is smaller that the one listed in Table V-2, Section E-5 of the MRMP EIA, since
1) the value in the EIA was calculated as the sum of maximum individual PAH concentrations
2) the values for the benzo(a)anthracene and benzo(a)pyrene groups were accidently included this sumation.

ATTACHMENT 2

DERIVATION OF CHRONIC AND ACUTE TOXICITY VALUES

The following table details which toxicity results were used to derive TID and CT water toxicity values used in the water quality modelling:

	TID Water				CT Water			
	Selected values		Corresponding toxicity units		Selected values		Corresponding toxicity units	
	LC-50[a]	IC-25[b]	TUa	TUc	LC-50[a]	IC-25[b]	TUa	TUc
Acute toxicity	43.4	-	2.3	-	37	-	2.7	-
Chronic toxicity	-	16	-	6.3	-	13.9	-	7.2

[a] results, expressed as %, from 96 hr. rainbow trout test
[b] results, expressed as %, from 7 day *Ceriodaphnia dubia* reproduction test

ATTACHMENT 3
DOSE RESPONSE CURVES FOR TOXICITY VALUES USED IN THE MRMP EIA WATER QUALITY MODELLING
(page 1 of 2)

Figure A. Dose response curve for 96hr rainbow trout test using TID water (LC50 = 43%)

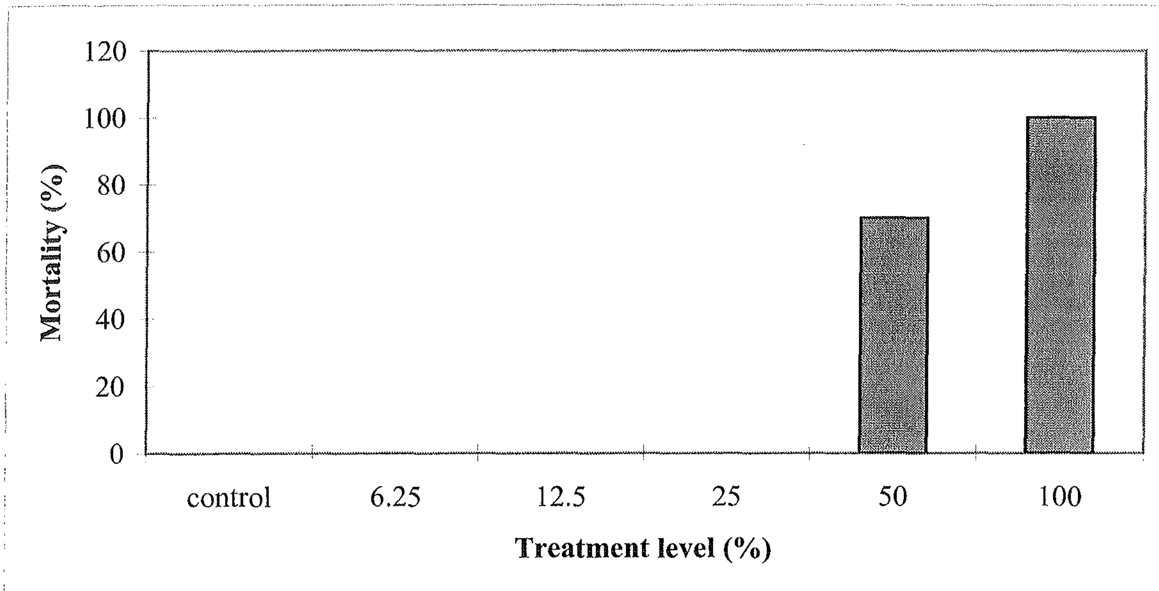
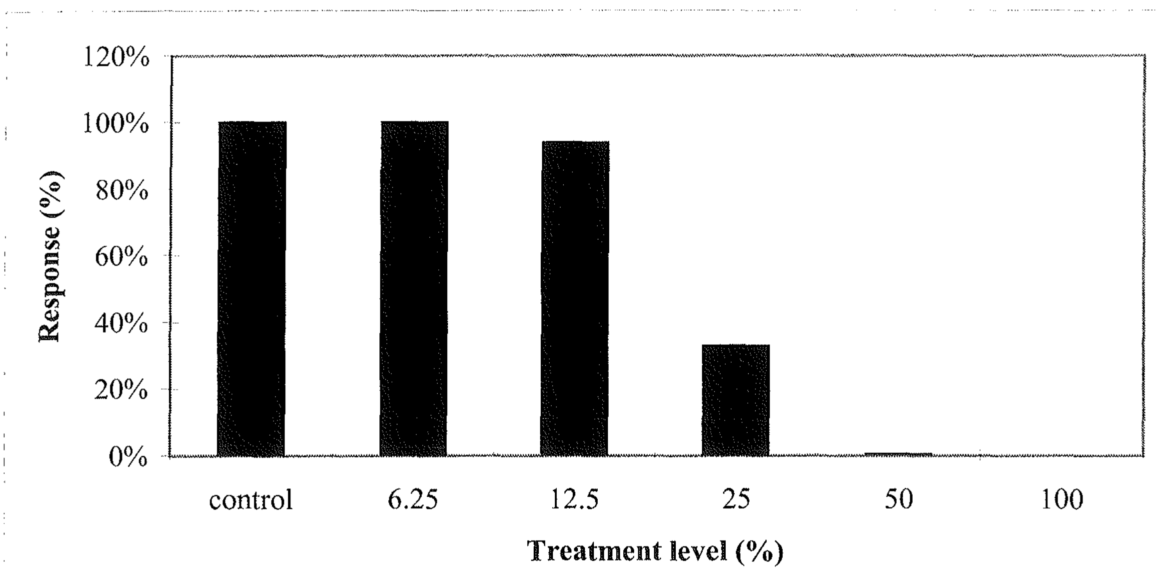


Figure B. Dose response curve for 7d *Ceriodaphnia dubia* reproduction test using TID water (IC25 = 16%)



ATTACHMENT 3 (cont'd)
DOSE RESPONSE CURVES FOR TOXICITY VALUES USED IN THE MRMP EIA WATER QUALITY MODELLING

Figure C. Dose response curve for 96hr rainbow trout test using TID water (LC50 = 37%)

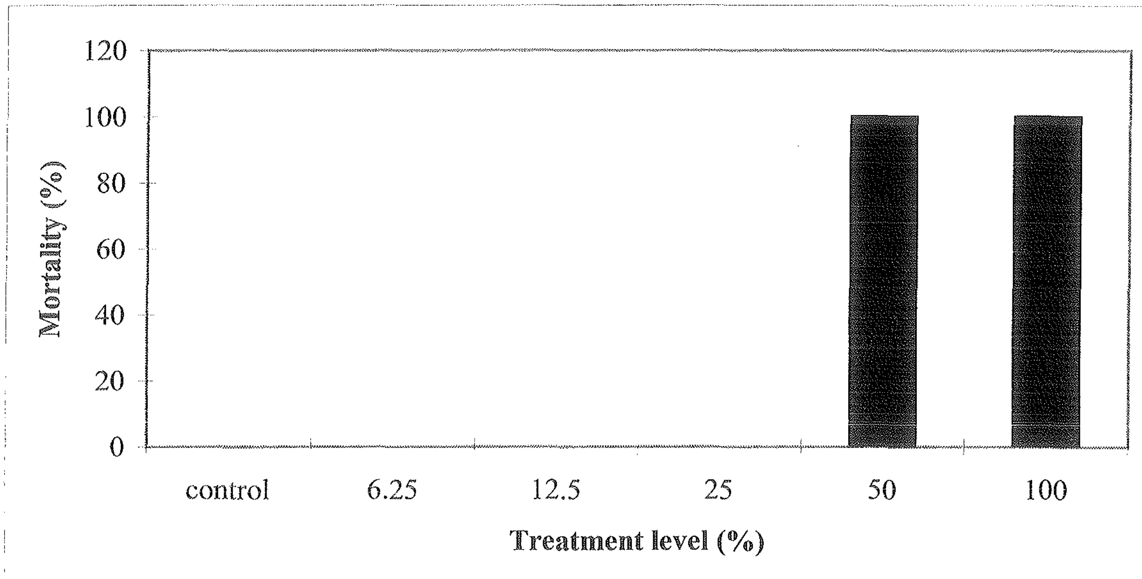
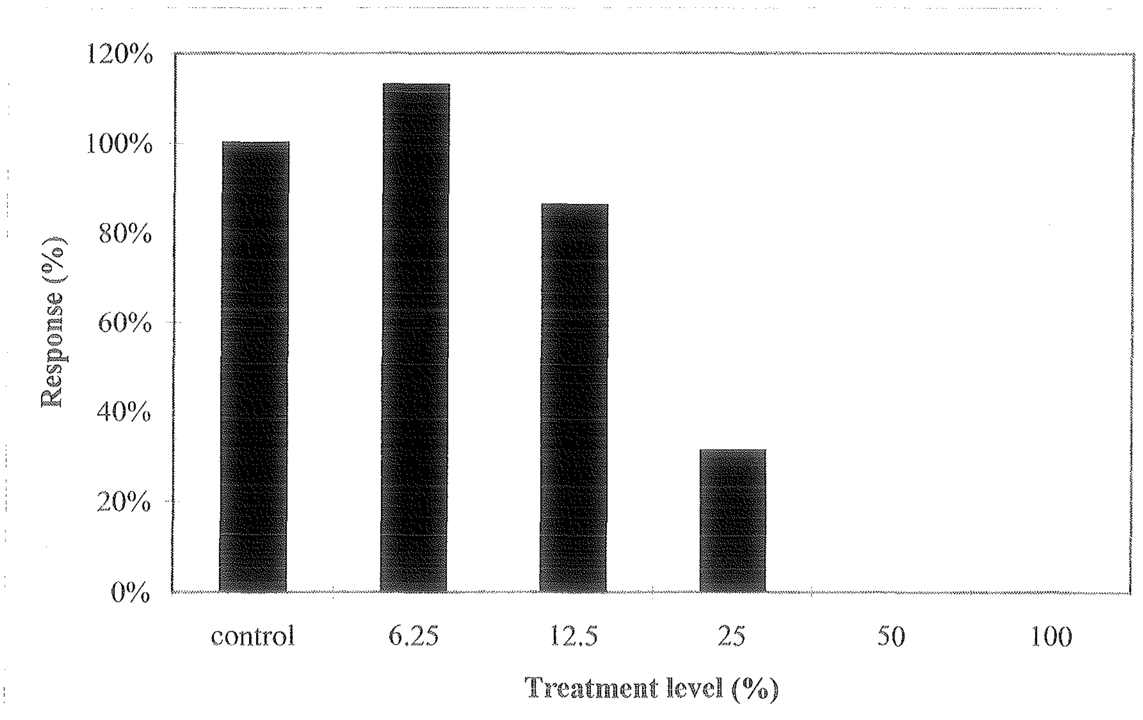


Figure D. Dose response curve for 7d *Ceriodaphnia dubia* reproduction test using CT water (IC25 = 13.9%)



ATTACHMENT 4

GROUPING OF CHEMICALS FOR SCREENING AND THE USE OF TOXICITY SURROGATES
(from Golder 1996)

Chemical Groupings

All chemicals detected were classified and grouped for screening purposes according to their structure and physiochemical and toxicological properties.

Closely-related chemicals were combined together to form chemical groups when insufficient human and/or ecological toxicity data were available to evaluate them individually. Maximum detected concentrations for each member of a chemical group were summed to provide a total concentration for each group in each sampling media. Within each chemical group, chemicals that were not detected in a particular media did not contribute to the overall group concentration.

For example, a chemical group designated the Naphthalene Group includes naphthalene, methyl naphthalene as well as the C_2, C_3, and C_4 substituted naphthalenes. Details of chemical grouping are summarized in Table 1.

Selection of Surrogate Toxicity Values for Screening Purposes

For the purpose of risk-based screening, all the chemicals of a group are assumed to have the same toxicological properties. Therefore, the quantitative toxicity value of a single compound (*i.e.,* the toxicity surrogate) was used to characterize the toxicity of the group. In selecting a toxicity surrogate for a group, the first choice was the parent compound found within that group. For example, naphthalene was chosen as the toxicity surrogate for the Naphthalene Group. For the Benzo(a)anthracene Group, sufficient data existed for two parent compounds (benzo(a)anthracene and chrysene). In this case, the chemical with the more protective toxicity value (benzo(a)anthracene) was selected as the toxicity surrogate.

When adequate toxicity data were not available or a more protective toxicity value was desired, a toxicity surrogate not present within the chemical group was chosen. For example, pyrene was chosen as a toxicity surrogate for the Phenanthrene and Dibenzothiophene Groups. Pyrene was selected as a surrogate for these groups for the following reasons:

- Pyrene and the constituents of these three groups are classified as noncarcinogens;
- Of the PAHs with sufficient toxicity data, pyrene has the second lowest reference dose (RfD) (naphthalene has the lowest RfD). However, there is greater uncertainty associated with the naphthalene RfD compared to the pyrene RfD.

Therefore, the use of pyrene as a toxicity surrogate for noncarcinogenic PAHs for which insufficient toxicity was available data is assumed to be sufficiently protective.

In some cases, toxicity surrogates were used for individual compounds (not groups of compounds) that have insufficient toxicity data. For example, acenaphthene was chosen as a surrogate for acenaphthylene based on their similar chemical structures and similar physio-chemical properties.

ATTACHMENT 4 (cont'd)

The toxicity surrogates used in the risk analysis for each of these chemical groups and other chemicals are listed in Table II-1.

Golder Associates Limited. 1996. Athabasca River water releases impact assessment. Report for Suncor Energy Inc. May 1996.

ATTACHMENT 4 (cont'd)

TABLE II-1

CHEMICAL GROUPINGS AND TOXICITY SURROGATES

Chemical / Chemical Groups	Contains Following Compounds	Toxicity Surrogate
Acenaphthene Group	• acenapthene • methyl acenaphthene	acenaphthene
Acenaphthylene	• acenaphthylene	acenaphthene
Benzo(a)anthracene Group	• benzo(a)anthracene/chrysene • methyl benzo(a)anthracene/chrysene • C_2 substituted benzo(a)anthracene/chrysene	benzo(a)anthracene[1]
Benzo(ghi)perylene	• benzo(ghi)perylene	pyrene
Benzo(a)pyrene Group	• benzo(a)pyrene • methyl benzo(b or k)fluoranthene/methyl benzo(a)pyrene • C_3 substituted benzo(b or k)fluoranthene/benzo(a)pyrene	benzo(a)pyrene
Biphenyl Group	• biphenyl • methyl biphenyl • C2 substituted biphenyl	biphenyl
Dibenzothiophene Group	• dibenzothiophene • methyl dibenzothiophene • C_2, C_3, and C_4 substituted dibenzothiophenes	pyrene
Fluoranthene Group	• fluoranthene • methyl fluoranthene/pyrene	fluoranthene
Fluorene Group	• fluorene • methyl fluorene • C_2 substituted fluorene	fluorene
Naphthalene Group	• naphthalene • C_2, C_3, and C_4 substituted naphthalenes • methyl naphthalene	naphthalene
Phenanthrene Group	• phenanthrene/anthracene • methyl phenanthrene/anthracene • C_2, C_3, and C_4 substituted phenanthrene/anthracene	pyrene
Acridine Group	• acridine • methyl acridine	anthracene
Quinoline Group	• quinoline • 7-methyl quinoline • C_2 alkyl substituted quinolines	pyridine

[1] Based on B(a)P and toxicity equivalent factors for ecological receptors due to lack of data for benzo(a)anthracene.
[2] Based on B(a)P and toxicity equivalent factors for ecological receptors due to lack of data for benzo(ghi)perylene.
[3] Based on phenanthrene as there was sufficient laboratory data for ecological receptors.

FORT MCKAY

BACKGROUND — CONSULTATION PROCESS

Shell and BHP are committed to meaningful consultation with the community of Fort McKay in order to understand the issues and concerns of the community regarding the proposed Muskeg River Mine Project. Shell has been meeting with the community of Fort McKay since the spring of 1997 to:

- share information on the project
- obtain preliminary and detailed feedback on the issues and concerns

Shell and the Fort McKay leadership have an agreement in place that outlines the guiding principles for:

- reviewing the project
- obtaining feedback from the community on the proposed development
- working towards agreeable solutions to mitigate concerns

The agreement includes the following principles:

- The application review team is to consist of a representative from Shell, Fort McKay First Nation and Fort McKay Local 122.

- The application review team's mandate is to facilitate assessment and consultation regarding issues arising from Shell's Muskeg River Mine Project.

- The application review will consider:

    - regional and environmental impacts, as outlined in the EIA terms of reference

    - socio-economic impacts, including employment and business opportunities and other matters of interest to Fort McKay residents

- The objectives of the review team are to:

- maximize cooperation and communication among the parties
- maximize each party's satisfaction with any decisions and the outcome
- expedite the project's review in a timeframe consistent with the regulatory process

This section summarizes the key environmental and socio-economic concerns raised by Fort McKay residents about the Muskeg River Mine Project, and contains an overview of proposed mitigation measures.

Weekly discussions are ongoing with Fort McKay, to better understand the issues and agree on appropriate ways of mitigation. These discussions involve:

- Fort McKay leadership
- elders
- health and wellness committee representatives
- school administrators
- others

Fort McKay will ensure that traditional knowledge is considered when reviewing the project and obtaining community input. In addition, Fort McKay has retained a consultant to help review the Muskeg River Mine Project EIA. Shell has provided funding to Fort McKay to ensure that the proper resources are in place to review both the application and the EIA as well as to get the required community input.

Discussions and the resolution of issues will be an ongoing process. Shell is committed to having meaningful consultation and working toward agreeable solutions with Fort McKay. The resulting mitigation measures will be formalized in the next few months. Shell's consultation with Fort McKay will continue throughout the regulatory process and, after project approval, into the construction and operation phase. Shell will provide the EUB with an update on these discussions later.

SOCIO-ECONOMICS

The key socio-economic concerns identified by Fort McKay are:

- employment
- education
- retaining traditional culture
- economic development
- physical infrastructure impacts

Employment

Fort McKay has identified several issues related to employment that include the:

- lack of funding for tuition and living support
- high cost of community upgrading programs
- lack of computer systems
- need to upgrade the school curriculum by adding employability skills training

Shell and BHP will continue to work with the community of Fort McKay to eliminate employment barriers where possible. The focus will be to collaborate with existing community employment resources and school and upgrading programs, to reinforce the importance of education in obtaining long-term meaningful employment.

Education

The issues raised by Fort McKay concerning education include the:

- lack of regular industry presence in community schools
- need to enhance student understanding of the importance of education
- low probability of school children finding meaningful long-term employment in the oil sands industry
- gaps between the Fort McMurray school systems and the Fort McKay school system

A Business Education Partnership Agreement is currently being developed between Shell and the Fort McKay School Board. This agreement will focus on a commitment to build a long-term, regular business education relationship. It will outline the timing and areas of involvement, based on identified needs. Shell is committed to working with Fort McKay to identify gaps between education and business needs.

Retaining Culture

Issues raised by Fort McKay for retaining culture include:

- loss of traditional lifestyle
- lack of replacement for traditional land use during the mine life cycle
- lack of resources to ensure that elders' traditional knowledge and expertise is transferred to the community
- desire to retain native identity

Shell is committed to understanding the issues associated with retaining culture and will develop a position statement to clarify this understanding with Fort McKay, Shell employees and contractors. Shell will work with the community to develop a cultural awareness program, which will help company employees and contractors understand culture, traditions and history of the area. In addition,

Retaining Culture (cont'd)

Shell will work with the community to develop projects to transfer traditional knowledge from elders to younger community members.

Economic Development

The community has raised the issue of economic development, and more specifically the need to match the capacity of the community to opportunities related to development in the area. The concerns include:

- no targets for local businesses
- lack of in-community support to liaise between the company and the contractors
- unknown process for identifying long-term contract opportunities

Shell is committed to developing a long-term relationship with the community that includes economic development. Fostering this relationship will include conducting contracting and business development workshops for local entrepreneurs, and regular meetings between local businesses and company representatives.

Physical Infrastructure Impacts

The issues raised by Fort McKay related to physical infrastructure impacts include:

- inadequate housing
- water treatment plant problems
- no local social services facilities for residents at risk or in recovery
- poor street lighting

Shell recognizes the need to continue discussions on community infrastructure impacts. Through the Athabasca Tribal Council, Shell will be part of a committee identifying First Nations community infrastructure needs, the barriers preventing development and recommendations for improvement. The committee will run parallel to the Regional Infrastructure Working Group.

ENVIRONMENT

The key concerns for the environment include:

- air quality and noise
- water and aquatic resources
- traditional land use and wildlife
- human health

Air Quality and Noise

The issues identified for air quality, including those linked to human health, are:

- NO_x
- VOCs from tailings
- particulates - $PM_{10/2.5}$
- noise

Potential mitigation for air quality issues include project design and operating solutions, such as:

- low NO_x burners on fixed plant equipment
- mine fleet efficiency and specifications
- dust control in mine operations
- solvent recovery efficiency
- noise abatement

In addition, it is essential that the community of Fort McKay participate in designing and executing monitoring programs. Project-specific monitoring will be linked with regional monitoring. Discussions are currently underway to receive community input on design-related opportunities and monitoring programs, to mitigate specific noise and emission concerns.

Water and Aquatic Resources

The issues identified for water and aquatic resources are:

- surface water flows in the Muskeg and Athabasca rivers
- water quality as a result of CT and process waters
- effect of fish and fish habitat

Monitoring programs will be developed to assess changes in flow rate, temperature and water quality for the Muskeg and Athabasca rivers (see Section 7.2, Monitoring and Research, in the Project Update). Shell will review the proposed monitoring programs with Fort McKay to ensure their input and involvement in data collection. The proposed monitoring program is for Shell's Muskeg River Mine Project and is linked to the broader regional RAMP monitoring program.

Shell has committed to additional studies related to fish health, which include fish health and tainting studies, life cycle testing and Y flow testing. Shell, in conjunction with Suncor and Syncrude, will conduct studies on the potential effects of CT water on fish and other aquatic organisms. The studies will be conducted before the project is operational, to ensure that results are incorporated into mitigation and future monitoring plans, if necessary. The studies will include the following:

Water and Aquatic Resources (cont'd)

- laboratory exposures of fish to CT water (fish health studies that will include an analysis of bioaccumulative potential, i.e., chemical levels in fish tissue)
- chemical characterization of CT water used for the tests
- acute and chronic toxicity testing on different aquatic organisms

Traditional Land Use and Wildlife

The main issues related to traditional land use and wildlife are:

- involving Fort McKay in the planning and execution of land reclamation
- using traditional knowledge to identify wildlife movement corridors
- identifying high-quality habitat for displaced animals of importance to the Fort McKay community, such as moose
- determining the effects of increased access to the area on wildlife viability

The final land use objectives and design for the reclaimed landscape for the Muskeg River Mine Project will be developed in a consultative process and will incorporate the recommendations of the Oil Sands Mining End Land Use Committee. Shell will work with the community of Fort McKay to ensure that traditional knowledge is integrated into this process and that Fort McKay is involved in the planning and execution of the reclamation work.

For the proposed project development area, Shell will:

- consult with Fort McKay trappers to identify wildlife movement
- involve Fort McKay in the design and execution of wildlife monitoring

Human Health

Issues identified for human health are:

- air quality effects
- human food pollution

Health effects from air emissions and water quality effects and human food pollution have been evaluated. The EIA has concluded that the project will not result in unacceptable health exposures for people working or living in the area.

Shell has committed to working with Fort McKay for the design and implementation of appropriate air monitoring in the community to ensure that air contaminants do not exceed the predicted levels.

OIL SANDS ENVIRONMENTAL COALITION

INTRODUCTION

Since September 1997, Shell has established an ongoing relationship with the Oil Sands Environmental Coalition (OSEC) to review the environmental aspects of Shell's application for approval of the Muskeg River Mine Project. OSEC is comprised of representatives from the:

- Fort McMurray Environmental Association
- Pembina Institute for Appropriate Development
- Toxics Watch Society of Alberta
- Environmental Resource Centre

As part of this ongoing cooperative consultation process, Shell has provided responses to an extensive issues list that was submitted to AEP as part of OSEC's Statement of Concern on March 25, 1998. These responses have been provided with the goal of addressing a number of OSEC's concerns and helping OSEC focus its concerns on key issues. Shell intends to work with OSEC to devise agreeable solutions to its key environmental concerns.

Where OSEC has identified errors in the application or EIA, the corrections have been included in an errata in Section 9 of the Project Update.

OSEC has raised questions related to the production of ozone from anthropogenic precursors in the Fort McMurray region. There are many scientific uncertainties associated with the actual amounts of ozone produced from anthropogenic precursors and, hence, on the magnitude of the effects of these secondary pollutants in the region. Although the scientific community is split on whether the meteorological conditions in the Fort McMurray region are conducive to the production of this secondary pollutant, Shell is participating with Syncrude and Suncor in the modeling of ozone production in the region and in a review of likely sources of anthropogenic precursors from oil sands facilities.

EUB No.	Exhibit No.
Information Requested By: OSEC	
Date of I.R. March 25, 1998	

Question No. **2.1.1 (1)**

Shell No. **OSEC 1**

Issue **Air Resources – LSA Definition**

Request

The EIA uses slightly different local study areas (LSA) for different medium. The air quality LSA is defined as a 41 km. by 41 km. area, centered on the proposed mine. Please provide the rationale for why the dimensions (i.e., 41 km x 4 km) for the air quality LSA was chosen.

Response

Because emissions from the Muskeg River Mine facilities come from low-level sources, including mine site equipment and relatively short stacks, the highest concentrations of emissions are likely to occur near the facility. Based on our experience, a local study area of 41 km x 41 km is appropriate to define the area which might be influenced by emissions from the Muskeg River Mine Project.

Question No. **2.1.1 (1)**

Shell No. **OSEC 2**

Issue **Air Resources – Baseline Emissions**

Request

No information is presented on the trends in regional air emissions over time.

2.1 Please provide emissions data for the historical period to present (i.e., baseline) for all major pollutants.

Response

2.1 Baseline emissions were provided in the EIA for SO_2, NO_x, CO_2, CO, PM, THC, and TRS. The Shell operation will not be a major source of SO_2 emissions. However, detailed Syncrude and Suncor historical data are available for SO_2 and virtually no data are available for other pollutants. Historical emissions of SO_2 were provided in the Syncrude Aurora and Suncor Steepbank baseline report (Figure 3.1, BOVAR Environmental 1996).

Some recent data are available for NO_x. The combined NO_x emissions from Syncrude and Suncor are 76 and 74 t/d for 1996 and 1997, respectively. This compares to the value of 77.8 t/d given in Table D2-1 of the Muskeg River Mine Project.

Earlier NO_x emissions estimates for Syncrude and Suncor are available for the period 1978 to 1982 from AEP (1984). The values expressed on a daily basis for the combined operations are:

- 1978 - 15.1 t/d
- 1979 - 13.7 t/d
- 1980 - 23.8 t/d
- 1981 - 27.1 t/d
- 1982 - 26.0 t/d

Note that Syncrude started operation in the summer of 1978. These values appear to be based on main stack emissions and do not include secondary stacks or mine fleet values. For the purpose of comparison, the 1996 emissions from the main stacks were 35.1 t/d. On the basis of main stack emissions, NO_x emissions are greater today than they were in the late 1970s and early 1980s.

Historical emission data for CO and PM emissions are in a state similar to that for NO_x. The database is biased to stack surveys conducted for the main stacks and does not include emission data from the secondary stacks or from mine fleet exhausts. Therefore, Shell does not have a historical database showing emission data for combustion products that include NO_x, CO and PM or for fugitive sources that include THC and TRS (see Attachment 1).

Request 2.2

Table D2-1 uses a mixture of different baseline years (and production levels) for the emissions presented. Some appear to based on 1994 data, others on 1995 or 1996 data, and other appear to be based on 1997 data. This is slightly confusing and should be clarified, as it does not give an accurate presentation of the baseline conditions.

Response 2.2

The information in Table D2-1 is based on the most recently available data at the time of filing the Muskeg River Mine EIA. The data relate to a time period of several years and provide a reasonable portrayal of baseline emissions.

SO_2 and NO_x emissions provided in Table D2-1 were obtained from the Syncrude and Suncor annual reports for 1996. As the annual reports do not reflect the full benefits of the Suncor FGD system, modifications to the 1996 emissions were made. Emissions for the other pollutants were obtained from the Aurora/Steepbank baseline report. The fugitive emission estimates are based on data collected in 1994 and 1995.

Request 2.3

Table D2-1 also does not show the VOC emissions, only THC emission. VOC emission data should be added. This should also be carried forward into the presentations of the other scenarios later in the EIA as well (i.e., sections E, F & G).

Response 2.3

See Section 7.3 (Ozone Formation) in the Project Update.

Request 2.4

Table D2-1 does not appear to include emissions from the residential / commercial sectors for Fort McMurray or Fort MacKay. What is shown in the table appears to be only the local traffic (transportation) emissions. The residential emissions have been previously estimated in the Syncrude Aurora Mine information. In addition, it is important to note what population these estimates are based on (see also Tables F1-2, F1-4 & F2-1).

Response 2.4 Table 2.4.1 summarizes non-industrial emissions as taken from the Aurora/Steepbank baseline report. The non-industrial emissions include residential, commercial and local traffic sources for both Fort McMurray and Fort McKay.

The totals match the values in EIA Volume 2, Table D2.1, except for CO_2, where the 376.5 t/d resulting from the residential use of natural gas was missed. The natural gas (residential) emissions are based on the 1995 gas consumption rate. Other estimates were made on the basis of a Fort McMurray population of 36,000 and 11,000 residences, and a Fort McKay population of 322 and 100 residences.

Given that the residential and traffic emissions are much less than the industrial emissions, we did not make adjustments for future population scenarios.

Table 2.4.1: Non-Industrial Emissions

	Aurora/Steepbank Baseline			
Compound	Local Traffic	Residential and Commercial	Total	Shell Muskeg River Mine Table D2.1
SO_2	0.18	0.005	0.185	0.2
NO_x	0.583	0.299	0.882	0.88
CO	2.19	1.721	3.911	3.9
CO_2	114.53	391.7	506.23	129
THC	0.904	1.154	2.058	2.1

Question No. **2.1.1 (1)**

Shell No. **OSEC 3**

Issue **Air Resources – Mine Clearing Emissions**

Request Section E2.2.1 does not describe the full range of air emissions associated with the burning of wood waste, it deals only with smoke and particulate emissions (Page E2-5 & E2-7).

Response EIA Volume 3, Part 1, Section E2.2, indicated that slash burning combustion products include NO_x, CO, CO_2, THC, PM and PAH, not only smoke and PM. Ambient concentrations of these compounds resulting from slash burning were not quantitatively calculated. The assessment was provided on a qualitative basis. See also the response to OSEC 30.

Question No.	**2.1.1 (1)**
Shell No.	**OSEC 4**
Issue	**Air Resources - Mine Fleet Emissions**

Request

The emission factors used to calculate and estimate mine fleet emissions appear to be based on lab or bench results and not on actual operating conditions in the field under load.

4.1 How will the emissions and emission factors from the mine fleet be validated?

Response

4.1 Emission factors will not be evaluated. However, after operations, Shell will participate in an ambient air quality monitoring program that will measure the effect of fleet NO_x emissions on ambient NO_x and NO_2 levels, thus validating the EIA predictions.

Request

The text indicates that there is a reduction in emissions expected as a result of enhanced performance standards from the US EPA and ECE for diesel engines. It is not clear if the factors given in the EIA are based on stationary sources or on mobile sources in the field (EIA Volume 3, Part 1, Page E2-34).

4.2 What plans does Shell have to monitor emissions from the mobile fleet sources in the field?

Response

4.2 The emission factors for the criteria pollutants (e.g., NO_x, CO, SO_2) were obtained from mobile source factors. For non-criteria pollutants (e.g., VOC, PAH), these factors were supplemented with additional data from stationary sources. The resulting emission factors used for the EIA are a blend of factors from a number of sources.

Shell does not propose to monitor or measure emission characteristics but will participate in a regional ambient air quality monitoring program (see the response to OSEC 4.1).

Question No.	**2.1.1 (1)**
Shell No.	**OSEC 5**
Issue	**Air Resources - Flaring Emissions**

Request

The EIA (Page D2-46 and D2-47) notes (pg. E2-18) that the emissions from flaring have not been identified or quantified as they are expected to be intermittent and of limited duration.

5.1 How frequently could these events occur?

Response 5.1 Flaring will only occur as a result of upset conditions associated with the froth treatment process.

Request 5.2 What percentage of time per annum might they occur?

Response 5.2 These upset conditions are not anticipated. Therefore, their frequency, duration, and magnitude cannot be determined. The flaring will be installed as a bypass operation precautionary measure.

Request 5.3 What would be the duration of the average flaring event or the worst-case event?

Response 5.3 The duration cannot be quantified at this stage of project development.

Request 5.4 What would be the potential magnitude of the emissions from one of these events?

Response 5.4 The potential magnitude cannot be quantified at this stage of project development.

Question No. **2.1.1 (1)**

Shell No. **OSEC 6**

Issue **Air Resources – Deposition Objectives**

Request The terms "critical load" and "target load" are used improperly in several places in the EIA (see list below). The correct term is the "interim critical load" for Alberta has been recommended by the CASA Target Loading Subgroup for use in Alberta for sensitive ecosystems (based on soils). At this point it has no regulatory standing and is essentially a reference level which is in the process of being validated. A target load for Alberta (or target loads) has not yet been determined. The term is used incorrectly on the following Pages: D2-24, D2-45, D2-48, D2-60 (x2), F2-8, F2-14(x2), & G2-6.

Response Yes, the term "interim critical load" should have been used throughout the report. The 0.25 keq/ha/a value is provided as a reference point.

Question No. 2.1.1 (1)

Shell No. OSEC 7

Issue **Air Resources – Model Predictions**

Request

The EIA (Page D2-46 and D2-47) uses different SO_2 emission rates in the predictive modelling than is presented in the base case inventory. SO_2 predictions (case 2) does not include intermittent flaring from Suncor (15.6 t/d), nor were the flaring or diverter stack emissions from Syncrude (1.3 t/d) as indicated in Table D2-1.

7.1 What is the basis for excluding these emissions?

Response

7.1 The data used for the predictive modeling were selected to provide what we believed is a representative future year baseline when the Muskeg River Mine Project was expected to come on stream.

Intermittent sources can have a significant year-to-year variability. In addition, flaring characteristics can change from event to event. For this reason, model predictions focused on continuous sources only. Excluding the Syncrude flare stack and diverter stack was not seen as significant as these stacks typically represent about 5% of Syncrude's total SO_2 emission.

The Suncor 1996 annual report identified intermittent flare emissions of 15.6 t/d and continuous flare emissions of 11.5 t/d for a total of 27.1 t/d. However, we believed that the intermittent flaring value would not necessarily be representative of a future year base case as we understood that Suncor was working to reduce SO_2 emissions due to flaring. This is supported by the 1997 Suncor reported values of 9.2 t/d for continuous flaring and 6.6 t/d for intermittent flaring (a total of 15.8 t/d). For the 2001 and Millennium emission scenarios, Suncor expects continuous flaring SO_2 emissions to be 7.3 and 1.3 t/d, respectively. These values compare to the 11.5 t/d value that we assumed for the Suncor flaring.

Request

7.2 The area (km^2) of the region that is predicted to have PAI values in excess of the interim critical load are inconsistently presented in the EIA. The areas presented on Page E2-46 do not match with the area provided in Table F2-7 and G2-3. In Section E the area under the baseline condition is given as 1,200 km^2 with the Project increasing this to 1,530 km^2 (pg. E2-46), while in other places the area under baseline conditions is given as 1,500 km^2.

Please clarify this discrepancy.

Response

7.2 The precise area numbers that should have been corrected in the final report, but were not, is the source of the discrepancies that you rightly identified. Corrected values are as follows:

Page E2-46:

- The area where the predicted PAI exceeds 0.25 keq/ha/a increases from 1,500 to 1,800 km^2.

- The area where the predicted PAI exceeds 0.50 keq/ha/a increases from 155 to 190 km^2.

Table F2-2:

- The area where the predicted PAI exceeds 0.25 keq/ha/a increases from 1,500 to 1,800 km^2 with the project and increases further to 2,500 km^2 with CEA.

- The area where the predicted PAI exceeds 0.50 keq/ha/a increases from 155 to 190 km^2 with the project and increases further to 315 km^2 with CEA.

Table G2-2:

- The area where the predicted PAI exceeds 0.25 keq/ha/a increases to 4,200 km^2 with RDR.

- The area where the predicted PAI exceeds 0.50 keq/ha/a increases to 975 km^2 with RDR.

For the 0.25 keq/ha/a contour, areas were rounded to the nearest 100 km^2. For the 0.50 keq/ha/a, areas were rounded to the nearest 5 km^2.

Request 7.3 There is an error in the 1st paragraph on Page D2-46; "Appendix I2" should read: "Appendix II".

Response 7.3 Error acknowledged.

Request 7.4 Figure D2-16 & D2-17 do not include background values for deposition. Why does Figure D2-18 include these but the former two do not?

Response 7.4 Total sulphate equivalent and total nitrate equivalent deposition values are intermediate calculations that provide an indication of the relative importance of SO_x and NO_x emissions. To provide a relative indication of respective contributions, background values were not included in the total sulphate and total nitrate values given.

The final calculation is expressed as a PAI. Only background values of PAI were included in the acid deposition contour presentations. This value is then used to evaluate the effects on environmental receptors.

Question No. 2.1.1 (1)

Shell No. OSEC 8

Issue **Air Resources – Model Prediction Plots**

Request 8.1 In general the air modelling output plots in the EIA are quite well presented. Placing the key reference information about the plot (i.e. model name, met. Data set, emissions data, etc.) on the figures is helpful. However, the model output plots in the EIA are all presented on a slightly different scale (even for those for the same area and scale). This make the direct comparison from one to the other difficult and somewhat frustrating. Also, the outputs are lacking in any surface reference details (i.e. rivers, lakes, etc.).

Response 8.1 The original plots did include some surface reference details. The use of differing software packages and subsequent photocopying resulted in these background features becoming faded as the material progressed to the final EIA. A rushed preparation resulted in different scales.

Request 8.2 A full set of the air model output plots should be provided on an equalized scale that would be suitable for overlaying one on top each other for direct comparison.

Response 8.2 The current output plots are not ideal but do present the required comparative information.

Question No. 2.1.1 (1)

Shell No. OSEC 9

Issue **Air Resources – Acid Deposition**

Request Provincial Scale Modelling (pg. D2-56) - this is actually a Western Canadian scale model run. The resolution of the referenced run of the RELAD model was done for all of western Canada at a 1° x 1° resolution. In addition this RELAD run was based on 1990 emissions data and has a number of areas of uncertainty, particularly the base cation data used for the Fort McMurray area. The run was done to provide a broad indication of the total acid input for the model domain based on the average for each of the grid cells. Comparisons between the RELAD model predictions at the 1° x 1° resolution and the CALPUFF model are difficult and complex. It should be noted that the RELAD model could be reconfigured and run at a smaller scale (i.e. higher resolution) for the region (for example at 0.25° x 0.25°).

Response We agree that the comparison between the CALPUFF and the RELAD predictions is difficult and complex. Nonetheless, as some of the reviewers of this EIA are the authors of the RELAD presentation, we believed we could add value to the assessment by providing such a comparison for reference purposes.

Shell will not rerun RELAD at a smaller scale.

Question No. 2.1.1 (1)

Shell No. OSEC 10

Issue **Air Resources – Emission Sources**

Request The table of emissions on Page D2-58 does not match the text. The 1996 emissions of SO_2 listed in the table should be higher (i.e. 463 t/d), the text notes that the 1997 emissions are expected to be much lower (i.e. 272 t/d). The table should also be clearly labeled.

Response The existing facilities in the oil sands area are in a period of transition with respect to SO_2 emissions. Therefore, the 1996 emissions were not believed to be representative of a future year base case. Our departure from the actual 1996 values was an attempt to recognize that improvements are expected to take place with these existing facilities.

See also the response to OSEC 2.2 and OSEC 7.1.

Question No. 2.1.1 (1)

Shell No. OSEC 11

Issue **Air Resources – Baseline Ozone Concentration**

Request 11.1 Table D2-13 (EIA Volume 2) shows only part of the available ozone data from the AEP station in Fort McMurray. There is data available from 1984 to present (not just from 1990 - which was the peak year). This presentation of the data is slightly misleading and incomplete. There are a couple of values in the table that appear to be different from the data provided by AEP and should be checked.

Response 11.1 Table D2-13 was taken from Table 7.1 in the Aurora/Steepbank Baseline Report. Normally, five years of recent data is regarded as sufficient to define ambient air quality. In the table, we have nearly eight years of data. We intentionally extended the period back to 1990 in order to include a peak year so we would not mislead the reader.

The values provided in the table were obtained from an electronic database provided by AEP. There are some differences between these values and those provided in the AEP annual reports. For example, the table indicates 4 hourly exceedances in 1994 whereas the AEP annual report indicates 2 hourly excellencies.

Request 11.2 Table D2-13 only shows data from the Fort McMurray (AEP) station, but the figures on the following Page (Figure D2-11) present data from three completely different stations (and from different time periods). The data for the Fort McMurray station should be presented graphically (for the entire period) and include the annual average trend line.

Response 11.2 We elected to present Fort McMurray data in a tabular format because of the length of the record (92 months). In contrast, the more limited monitoring data from the other locations are provided in a graphical format because of the shorter period.

Request 11.3 It should be noted in the text that the ambient air quality guideline values for the different averaging periods (i.e. hourly, daily, and annual) are based on different receptor impacts and each have a different biological relevancy.

Response 11.3 We agree that differing guideline values are based on differing receptor considerations. Therefore, the selection of 1 hour, 24 hour and annual average values acts as a surrogate for more complex exposure-receptor relationships.

Request 11.4 There is an error in the 3rd paragraph on Page D2-34; the ozone value of 0.055 should read "55 ppb.".

Response 11.4 Error acknowledged.

Question No. 2.1.1 (1)

Shell No. OSEC 12

Issue **Air Resources – Ozone Guideline**

Request The AEP ozone guideline is inconsistently presented in the EIA, in terms of the units used. For example, on page E2-53 it is referred to as 160 $\mu g/m^3$, and elsewhere it is referred to as 82 ppb.

Response Agreed.

Question No. 2.1.1 (1)

Shell No. OSEC 13

Issue **Air Resources – Ozone Prediction**

Request Note that there is an error in the last paragraph on page E2-54. "BOVAR 199b" should read "BOVAR 1996b".

Response Error acknowledged.

Question No.	**2.1.1**
Shell No.	**OSEC 14**
Issue	**Air Resources – Tailings Pond Emissions**

Request There appears to be text missing or misplaced following the 3rd full paragraph on page E2-22.

Response Error acknowledged.

Question No.	**2.1.1 (1)**
Shell No.	**OSEC 15**
Issue	**Air Resources - CT Emissions**

Request There is no emissions data presented on the potential emissions from the CT process as it establishes into a final landscape (pg. E2-24).

15.1 How will this information be gathered?

Response 15.1 Information will be gathered from the Syncrude and Suncor demonstration and commercial CT deposits over the next few years, well before CT depositing begins for the Muskeg River Mine in 2006.

Request 15.2 When will estimates be available?

Response 15.2 Estimates for the Muskeg River Mine deposits can be made based on the information from Syncrude and Suncor's CT deposits over the next few years.

Request 15.3 Can these emissions be modeled for selected points in time towards the establishment of a final CT landscape?

Response 15.3 Research is planned to assess the mechanisms of gas generation in CT deposits. With such research data in hand, modeling might be possible.

Fugitive emissions associated with CT that is incorporated into the reclaimed mine pits will be measured as part of Shell and BHPs overall fugitive emissions program. The details of the monitoring program will be defined later.

Question No. 2.1.1 (1)

Shell No. OSEC 16

Issue **Air Resources – Air Quality**

Request There is an error on Page E2-26 in the first paragraph of section E2.3. The reference to Table D1-4 should be to Table D1-7.

Response Error acknowledged.

Question No. 2.1.1 (1)

Shell No. OSEC 17

Issue **Air Resources - NO_2 Concentrations**

Request Table E2-16 presents the expected NO_x (and NO_2) emissions associated with the project. The annual NO_2 concentration presented in this table appears to be less in the combined scenario (i.e., Muskeg + Suncor + Syncrude) than for the Muskeg River Mine alone.

17.1 What is the basis for this?

Response 17.1 All annual average NO_2 concentrations should track the annual average NO_x concentrations. The value of 76 $\mu g/m^3$ should be changed to 65 $\mu g/m^3$. As a result of rounding, the annual values for all cases are equal to 65 $\mu g/m^3$.

Request 17.2 Is this an error?

Response 17.2 Error acknowledged.

Request 17.3 There is an error in Table E2-16. The annual NO_2 guideline is 60 ug/m^3 not 100 as indicated.

Response 17.3 Error acknowledged.

Question No.	**2.1.1 (1)**
Shell No.	**OSEC 18**
Issue	**Air Resources – Summary**

Request Table E2-15 does not present emissions data for VOCs. This should be added.

Response See Section 7.4 (Volatile Organic Compound Emissions) in the Project Update.

Question No.	**2.1.1 (1)**
Shell No.	**OSEC 19**
Issue	**Air Resources - Mine Fleet Fuel Use**

Request The maximum fuel consumption is predicted to be approximately 73 million litres per year (200,000 L/d). The use of this fuel will require transfers from storage tanks to refueling trucks and into the mine fleet vehicles themselves. This could mean as many as 3-4 transfers. Each time the fuel is transferred, hydrocarbon vapours are released.

What are the estimated VOC emissions from this source? Has this source been included in the estimated VOC emissions from the mine? What consideration has there been for the use of vapour recovery?

Response The US Environmental Protection Agency (EPA) is currently evaluating emissions from off-road vehicles and we are not aware of estimations of refueling emissions associated with diesel engines. For gasoline-fueled engines, non-exhaust VOC emissions can account for a substantial portion of the hydrocarbon (HC) emissions. Diesel fuel has a low volatility compared to gasoline, so non-exhaust VOCs are much lower and, therefore, a less significant source of non-exhaust VOC emissions. Consequently, these sources were not included in VOC emissions from the mine.

Harvey (1998) indicates HC crankcase emissions from gasoline engines are equal to 33% of the exhaust HC. In contrast, crankcase emissions from diesel engines are only 2% of the exhaust HC. The comparison of these values might provide a relative indication of evaporative HC emissions associated with the use of gasoline versus diesel fuel. VOC emissions associated with diesel are expected to be lower than those associated with gasoline. At this stage, we do not have a direct indication of how low. Some equipment will refuel directly from the bulk storage. The remaining mining fleet will be refueled from a mobile tanker. The fuel transfer operation will be via a closed coupling system, minimizing the potential for vapours to be vented to the air.

The VOCs from refueling are expected to be minimal, and have been included in the emissions estimated for the mine.

Question No. 2.1.1

Shell No. OSEC 20

Issue **Air Resources - Tailings Pond Emissions**

Request Suncor's latest hydrocarbon emission inventory of their tailings pond indicates a much higher rate of emission of VOC and methane than earlier surveys.

How does the estimated hydrocarbon emissions for the project (based on the Syncrude survey) compare with the recent results of the Suncor survey of tailings pond hydrocarbon emissions?

Response See Section 7.4 (Volatile Organic Compound Emissions) in the Project Update.

Question No. 2.1.1 (1)

Shell No. OSEC 21

Issue **Air Resources - Baseline Emissions**

Request Table F1-2 mixes the current operating levels with the approved levels (also see Table F1-3 & Table F14).

Operator	Bitumen Production (bbl/d) 1997	Synthetic Crude Production (bbl/d) 1997
Suncor	120,000	96,000
Syncrude	260,000	213,000
Gibson	2,000	0
Total	382,000	309,000

Response Table F1-2 is intended to refer to baseline conditions for both Suncor and Syncrude. The production figures referred to in this table should be referred to as current production capacity, not approved capacity.

Question No. 2.1.1 (1)

Shell No. OSEC 22

Issue **Air Resources - Environmental Parameters**

Request

Table F1-4 does not include emissions of VOCs and CO_2. These should be included for completeness. The table should also include emissions from the category of "other" emission sources from Table D2-1. The later should be adjusted for the predicted population level (and provide assumed population). Table F1-4 could be re-ordered by company for easier reading. A similar table should also be presented for the RDR in Section G.

Response

A CEA assessment of greenhouse gas (i.e., CO_2) emissions was not undertaken as these emissions are not assessed on a typical EIA cause-effect basis like other EIA parameters. Specifically, greenhouse gas emissions are typically addressed on a corporate basis. For this reason, greenhouse gas emissions associated with other developments were not provided.

VOC emission estimates were not provided, based on considerations provided in Section 7.4 (Volatile Organic Compound Emissions) in the Project Update.

Future adjustments for increased population were not made as these emissions are low in comparison to the industrial sources.

See also the response to OSEC 3.

Question No. 2.1.1 (1)

Shell No. OSEC 23

Issue **Air Resources – Emission Projections**

Request

23.1 Table F2-1 (EIA Volume 4, Page F2-2) does not include emissions of VOCs and CO_2. These should be added for completeness. The emissions in the category "other" sources needs to include both transportation and residential / commercial emissions, and to be adjusted for the predicted population increase (and provide the population used).

Response

23.1 See the response to OSEC 3.

Request

23.2 Note that the THC emissions for "other" presented in Table F2-1 are less in the future predicted scenario than in the baseline.

What is the basis for this? Is this an error?

Response 23.2 No, this is not an error.

The "other" values were not updated. In Table D2-1 (baseline), the THC was given to one decimal place (i.e., 5.4 t/d).

In Table F2-1, the THC emissions were rounded to zero decimal places (i.e., 5 t/d). This is not a reduction but an artifact of inconsistent presentation.

Request 23.3 Table F2-1 and the combined CEA scenario does not include the maximum SO_2 emissions that Syncrude could emit (i.e. 220 t/d) if they were to produce at their approved production level (see footnote to Table F2-1). These emissions should be included in the modeled predictions.

Response 23.3 This was viewed as an intermediate emission scenario and was not evaluated. The 220t/d would increase the sulphate values depicted in EIA Volume 4, Figure F2-1 (by up to 10%) but would not affect the nitrate values depicted in Figures F2-2 and F2-3. This would not have a major effect on the PAI pattern given in Figure F2-4.

Request The modeled concentrations of NO_2 in the LSA are presented in Figure E2-5. This is based on the ISC3BE model and OSLO met. data. Appendix II presents NO_x concentrations for the LSA using the CALPUFF model (Fig. II-8) and the ISC3BE (Fig. II-7) - but using two different met data sets.

23.4 Why was a different met data set used?

Response 23.4 We used OSLO meteorological data for LSA predictions of NO_x. This was viewed as being more representative of the Muskeg River Mine emissions, given the proximity of the two locations and the ground-based nature of emissions from the project. We used the Mannix-based meteorology when using CALPUFF to predict deposition as the meteorological data from this site had the additional parameters required to predict deposition.

Request 23.5 What would the CALPUFF plot look like with the OSLO data?

Response 23.5 The CALPUFF model has not been run with the OSLO data. See also the response to OSEC 23.4

Request 23.6 Emissions from the Mobil Oil Kearl Mine are included in the combined CEA scenario as indicated on Page F2-4 (EIA Volume 4). This project (i.e. Mobil's Kearl Mine) does not fall in the same grouping as the others, and should only be included in the Regional Development review.

Response 23.6 Error acknowledged. Kearl mine and upgrader emissions were only included in the RDR.

Question No. 2.1.1 (1)

Shell No. OSEC 24

Issue **Air Resources – Monitoring**

Request 24.1 The information on the ambient monitoring stations (Figure D2-1 & Table D2-2) is slightly out of date. This should be updated to show all of the ambient monitoring stations that are now a part of the regional network. The table should be expanded to include the years of operation for each station (as well as an updated parameter list).

Response 24.1 The February 1998 Wood Buffalo air emissions monitoring locations are shown, along with the parameters measured at each site, in Figure 1 at the end of this section.

Request 24.2 Section E2.8 makes recommendations for ambient monitoring in the Project area. This monitoring should also include ozone concentrations.

Response 24.2 The monitoring of ambient ozone values is best done on a regional basis. The monitoring of ozone adjacent to the mine will result in values lower than background because of scavenging by NO. However, Shell will participate in the Wood Buffalo Environmental Association program, which includes ambient ozone measurements at regional stations. See also the response to AEP 35 on Shell's Monitoring Committee.

Question No. 2.1.1 (1)

Shell No. OSEC 25

Issue **Air Resources - Greenhouse Gas Emission Inventory and Forecasts**

Request Greenhouse gas emissions are presented in the baseline (EIA Volume 2, Section D2.7 & Table D2-1) and project (Section E2.7) sections of the EIA, but they are not presented in the CEA or RDR sections. Projected emissions of CO_2 and other GHGs are available for the approved projects and should be presented. An estimate of the projected GHG emissions from the region under the CEA and RDR should also be presented. Increases in the regional population base would need to be included in this estimate.

Response See the response to OSEC 22.

Question No.	**2.1.2 (1)**
Shell No.	**OSEC 26**
Issue	**Air Emissions and Air Quality**

Request

The Oil Sands Environmental Coalition is concerned that emissions of air pollutants anticipated from the Project, especially when combined with those from existing and approved operations, could have a significant adverse affect on the regional air quality and on a number of air quality issues and receptors.

Shell Canada has proposed a number of process improvements that reduce the amount of emissions that otherwise would have been emitted. However, even with these improvements, the Project would still result in significant emissions of air pollutants into the atmosphere. Emissions of air pollutants anticipated from the Project are presented in sections E & F of the EIA.

OSEC's concern is based on a high degree of uncertainty regarding the capacity of the region to absorb and assimilate the anticipated increase in total emissions (i.e. the cumulative impacts).

Response

No response necessary.

Question No.	**2.1.2 (1)**
Shell No.	**OSEC 27**
Issue	**Air Emissions and Air Quality - NO_x Emissions**

Request

Emissions of NO_X from the Project are predicted to be 12 t/day, which constitute an increase of 15.3% over current regional emissions (baseline).

27.1 NO_X emissions from the Project will mainly come from the mobile fleet in the mine (i.e. 84%). NO_X emissions are important air pollutants as they are active in a number of air issues (i.e. ground-level ozone, acidification, greenhouse gases), and as toxics for plants and animals.

Response

27.1 The modeling and some monitoring in the area have confirmed the potential for high NO_x adjacent to truck-and-shovel mines. The results, however, indicate NO_2 levels are less than the hourly ambient air quality guideline. The high values predicted and observed adjacent to an open pit mine are typical of those observed at urban air monitoring stations.

For example, maximum 1995 NO_x concentrations in Edmonton and Calgary ranged from 0.51 to 1.07 ppm (960 to 2038 $\mu g/m^3$). Corresponding NO_2 values ranged from 0.10 to 0.14 ppm (190 to 267 $\mu g/m^3$). This is similar to the maximum values observed adjacent to the Syncrude North Mine (1640 $\mu g/m^3$ for NO_x and 213 $\mu g/m^3$ for NO_2).

Request 27.2 Given the trend in the region to increased NO_X (i.e. 2.5 current over next 15 years) and the prominence of this air pollutant in key air issues it is essential that emissions of NO_X be minimized. A regional limit on NO_X emissions may be necessary to control the impacts related to NO_X.

Response 27.2 The motivation to reduce NO_x emissions from a truck-and-shovel mine is closely tied to the economic operation of such a mine. The desire to optimize the mine operation by reducing haul distances and other factors that reduce fuel consumption will work towards reducing NO_x emissions.

Question No. **2.1.2 (1)**

Shell No. **OSEC 28**

Issue **Air Emissions and Air Quality - Hydrocarbon Emissions**

Request 28.1 Emissions of VOCs are projected to increase as a result of the Project. No numbers are presented for VOCs for the region, but the THC (Total Hydrocarbon) emissions from the Project are predicted to be 4 t/day, which will constitute an increase of approximately 9% over the current baseline.

Response 28.1 The reasons for presenting THC rather than VOCs are given in Section 7.4 (Volatile Organic Compound Emissions) in the Project Update. Although the numbers are presented on a THC basis, we agree that there would be a corresponding increase in VOC emissions.

Request VOCs are important emissions involved in the formation of ground-level ozone and as hazardous air pollutants. THC, which includes methane, is important as a greenhouse gas.

28.2 PAH emissions, which are a sub-set of THC and VOCs, are expected to increase in the region as a result of the Project. PAHs are an important hazardous air pollutant. PAHs can be carcinogenic; don't readily breakdown in the environment and can bio-accumulate.

Response 28.2 The main PAH emissions in the region result from the mine fleet exhausts, from the Syncrude main stack and from the Suncor Energy Services stack. Additional PAH emissions can result from the residential use of wood for supplementary heating or for recreational use.

The Millennium Technical Reference report indicates the following PAH emissions:

- Syncrude existing mine 1.28 kg/d
- Suncor existing mine 0.80 kg/d
- Aurora (North and South) 1.67 kg/d
- Shell Muskeg River Mine 1.01 kg/d

The PAH emissions are directly projected to the full use. Existing Syncrude main stack PAH emissions are 2.56 kg/d and the existing Suncor FGD stack PAH emissions are 0.1 kg/d. Estimates from wood heating were not made.

The Syncrude main stack PAH emissions are confirmed as 2.56 kg/d.

Question No. 2.1.2 (1)

Shell No. OSEC 29

Issue **Air Emissions and Air Quality – Particulate Emissions**

Request 29.1 Emissions of fine particulates (PM10) from the Project are predicted to be 0.8 t/day, which would constitute an increase of approximately 7% over the current baseline.

Response 29.1 No response necessary.

Request 29.2 Fine particulates are important emissions in human and animal health impacts.

Response 29.2 The inhalation of fine particulates is important to consider in terms of human health. The inhalation of fine particulates by animals is not typically evaluated because of limited data. See EIA Volume 3, Part 1, Page E12-33 and the response to OSEC 55.5 for further details on the evaluation of fine particulates and human health.

Question No. 2.1.2 (1)

Shell No. OSEC 30

Issue **Air Emissions and Air Quality - Mine Clearing Emissions**

Request The Oil Sands Environmental Coalition (OSEC) is concerned about increased emissions from a few specific sources associated with the Project for which there appears to be additional emission reduction opportunities.

Emissions from the burning of mine clearing slash contribute to regional air quality problems. This is an avoidable emission source of greenhouse gases, PAHs, etc., and is a waste of a valuable organic resource. There appear to be a number of opportunities to minimize the emissions generated from this activity. These opportunities include increased utilization of the salvage wood fibre, chipping the slash for use in reclamation activities, and use of the slash as a supplementary fuel. There may also exist opportunities to use portions of this material stream in some form of regional composting application. If combustion of the residual wood waste is necessary, then it should be done in such a way as to minimize the emissions.

What other options to the burning of waste wood has Shell evaluated?

Has Shell included the emissions from this source in the EIA, CEA and RDR?

Response

Alternatives to the burning of brush are being examined by the oil sand companies, OSEC and AEP. No resolution on alternatives has yet been reached. However, some general comments are that:

- the burning of brush and clearing of slash is an effective and accepted method of disposing of these materials
- there is no need for wood chips for reclamation early in the mine life and even later there will be an abundance of organic materials more suited to reclamation needs
- Shell will optimize the use of wood fibre through on-site opportunities in reclamation and follow field practices for better burning efficiencies

These emissions were not included in the EIA, CEA or RDR.

Question No. **2.1.2 (1)**

Shell No. **OSEC 31**

Issue **Air Emissions and Air Quality - Mine Fleet Fuel Use**

Request

Emissions from the mobile mining fleet is an important component in the overall growth of NO_x emissions. The NO_x emissions are produced from the combustion of diesel fuel and have increased in the region with the switch to mobile truck and shovel mining. Emissions from this source are expected to continue to grow. What plans does Shell have to minimize and reduce the combustion emission from the mine fleet?

Response

The amount of mine fleet exhaust emissions is based on the quantity of diesel consumed. Shell will strive to plan and manage an efficient mining operation, with particular attention to the efficient use of mobile equipment. These areas of attention will include:

- minimizing haulage distances
- constructing and maintaining good roads
- optimizing the use of equipment with an appropriate fleet dispatch system

Engine emission factors will be an integral part of the evaluation when purchasing new equipment.

Question No. 2.1.2 (1)

Shell No. OSEC 32

Issue **Air Emissions and Air Quality - Tailings Pond Emissions**

Request

Emissions from the oil sands tailings ponds is another area with which OSEC continues to be concerned. Evaporative and fugitive emissions of VOCs from the large ponds will only grow with increased activity in the area.

32.1 What plans does Shell have to inventory these emissions?

Response

32.1 The emissions will be inventoried for purposes of developing emission factors for regular reporting.

Request

32.2 What plans does Shell have to minimize and reduce VOC emissions from the ponds?

Response

32.2 The main source of VOCs are froth treatment tailings. The tailings solvent recovery unit will be used to minimize the loss of froth treatment solvent to the tailings settling ponds.

Question No. 2.1.3 (4)

Shell No. OSEC 33

Issue **Ambient Air Quality Objectives - NO_2 Concentrations**

Request

The Oil Sands Environmental Coalition is concerned that emissions from the Project, in conjunction with existing and predicted emissions from other sources, will result in a decrease in the regional air quality and an increase in the number of exceedances of the Ambient Air Quality Objectives. These exceedances indicate a higher level of risk of impact and injury to ecosystems, plants and animals (including humans).

33.1 According to the EIA NO_2 concentrations in the region will increase due to the Project. The combined CEA scenario (i.e. baseline + approved + Project) predicts that the additional emissions will result in exceedances of the annual NO_2 guideline.

Response

33.1 The predicted annual average NO_2 concentration of 71 $\mu g/m^3$ is predicted to exceed the guideline value of 60 $\mu g/m^3$. As indicated in EIA Volume 4, page F2-4, this exceedance is predicted to occur adjacent to the respective mines. The areas adjacent to the mines are already disturbed areas with restricted access.

As mentioned in OSEC 11.3, the air quality guidelines act as a surrogate for the complex receptor-exposure interactions. For human health exposures, the primary concern focuses on the shorter term hourly and daily exposure levels. Annual average guidelines are focused more on vegetation responses.Therefore, the implication of exceeding the annual guideline value will be from a vegetation perspective. Consequently, Shell proposes to conduct ambient monitoring adjacent to the mine pits to confirm the predicted ambient levels.

Request 33.2 While the hourly and daily guidelines are not expected to be exceeded under these conditions, a significant portion of the buffer would be used up (i.e. 67-75% of the guideline values are predicted).

Response 33.2 No response necessary.

Question No. **2.1.3 (4)**

Shell No. **OSEC 34**

Issue **Ambient Air Quality Objectives - Ground-Level Ozone Concentrations**

Request

Emissions of ozone precursors from the combined CEA scenario (i.e. baseline + approved + Project) are predicted to lead to concentrations of ozone which exceed the AEP Air Quality guidelines (see below).

Response

Shell is currently participating with Syncrude and Suncor to refine ozone modeling efforts for the proposed development scenarios (see the response to OSEC 35.7). For the results of the ozone modeling, see Section 7.3 (Ozone Formation) in the Project Update.

Question No. **2.1.4 (1)**

Shell No. **OSEC 35**

Issue **Ground Level Ozone – Increased Emissions**

Request

The Oil Sands Environmental Coalition is concerned that emissions of NO_x and VOCs from the Project, in conjunction with existing and predicted emissions from other sources, will result in increased formation of ground-level ozone and increased concentrations of ozone in the region. The Coalition is further concerned that these increased concentrations will result in increased exceedances of the AEP guidelines and increased impacts on receptors.

Emissions of ozone precursors (i.e. NO_x and VOCs) in the region have increased over the historic period. Emissions of NO_x have increased steadily and are predicted to continue to do so into the future. Emissions of NO_x are expected to more than double over the next 15 to 20 years. Anthropogenic emissions of VOCs have also increased steadily over the historic period, but have begun to stabilize and decrease in 1990. However, forecasts indicate a renewed modest growth of VOC emissions over the next 15 to 20 years.

35.1 The EIA (pg. D2-32) indicates that current ozone concentrations in the region exceed the maximum daily guideline for approximately 135 days per year. This represents about 37% of the time, mainly occurring in the spring and summer. The annual guideline (federal - 15 ppb.) for ozone is exceeded all of the time. The maximum hourly average guideline (82 ppb.) was last exceeded in 1993, although the maximum hourly values for the past few years have averaged about 67 ppb. (82% of the guideline value).

Response 35.1 Most of the daily ozone exceedances occur during March, April, May and June. During March and April, vegetation is relatively dormant. Vegetation is most active (and vulnerable) in May and June. Because of this concern, Shell is participating in updating ozone modeling.

Request 35.2 The EIA makes the statement on Page D2-34 that high ozone values occurred during times when emissions of the precursors were lower. An analysis by OSEC of the ambient ozone data from the AEP monitoring station in Fort McMurray does not support this statement. The trends in regional emission of ozone precursors (i.e. NO_x & VOCs) show reasonable correlation with the ozone concentration trends for the same period (1984 - 1997).

What evidence is there to support the statement that the peak ozone values occurred during periods of higher emissions?

Response 35.2 The statement was made with respect to data collected by the AOSERP program for the period 1977 to 1980, when compared to the more recent emission data for 1990 to 1997. As discussed in OSEC 2.1, NO_x emissions were expected to be lower for the earlier period. We do not have an indication of the VOC emission during this earlier period. We speculate that it would have been lower as the SCO production rates were lower during this earlier period.

We still contend that high ozone values were observed during a period when precursor emissions were lower. This might be more related to monitoring location, rather than to temporal trends.

Request 35.3 Please present a plot of the trends in annual ozone precursor emissions vs. annual ozone concentrations for the period 1984 to present.

Response 35.3 A plot of trends cannot be undertaken, as consistent data are not available.

Request 35.4 The ambient ozone guidelines are currently under review, both here in Canada and in the United States. New guidelines/objectives for ozone are expected in the near future. While the form that these will take and the value are not yet known, it is almost certain that they will be more stringent than the current guidelines. In planning the Project for the future, it would be prudent to build in a degree of conservatism into the assessment to anticipate the new ozone guidelines. All assessments have agreed that the current guidelines are inadequate to protect human health and ecosystem health.

Response 35.4 It is not clear whether the new guideline will be more stringent than the current guidelines. The current guidelines (short-term) are based on a single one-hour occurrence. New guidelines might be based on a longer averaging period (e.g., 8 hours) or on the sum of concentrations that are greater than a given threshold.

Although the threshold might be more stringent numerically, the application might be less stringent because of averaging over a longer time period.

Request 35.5 Ozone predictions using the SMOG model were done for the region in 1993 and 1996. Even though the SMOG model is outdated and is known to under-predict ozone concentrations, the results of the modeling indicate that ozone concentrations in the region are expected to increase as a result of increased emissions of ozone precursors from anthropogenic sources. The model predicts that ozone concentrations in the region will likely exceed the current hourly guideline.

Response 35.5 The model is outdated, but we are not aware of any references that show the model consistently under-predicts ozone. The model in its application to the oil sands region indicated that there was the potential for the photochemical production of ozone. For the example cases provided, the maximum values exceeded the 82 ppb hourly guideline.

Request 35.6 The predictions of the SMOG model, even with all of its short-comings, does support the hypothesis that there is potential for the ozone concentrations in the region to exceed the one hour guideline (82 ppb.), as well as result in an overall increase in ozone concentration in the region. There is an urgent need to have a better understanding of the ozone situation and limitations of this region.

Response 35.6 Steps are being taken to improve our understanding of the ozone situation through the application of the CALGRID model for the region (see the response to OSEC 34 and OSEC 35.7).

Request 35.7 What plans does Shell have to conduct enhanced ozone modelling for the region using the more advanced ozone models now available (i.e. CALGRID)?

Response 35.7 Shell is working with Syncrude and Suncor to support the application of the CALGRID model to the region. Plans are to apply the model on an event basis to predict ozone concentrations during the period when high ozone concentrations have historically been observed (end of April and beginning of May) and to a period when temperatures are the warmest (end of July and beginning of August). The application of the model will be based on the most recent estimates of NO_x and VOC emissions. The CALGRID modeling relevant to the Muskeg River Mine will be included (see Section 7.4 (Volatile Organic Compound Emissions) in the Project Update).

Request 35.8 The EIA makes the statement (pages D2-60 and E2-53) that naturally occurring high ozone level occur in the spring.

How much influence on these high values would the anthropogenic emissions have?

Is there any evidence from elsewhere to support the theory that the spring time values are solely the result of naturally occurring ozone?

Response 35.8 The first event for the application of the CALGRID model was selected to help answer this question (see the response to OSEC 35.7). The papers that were referenced in the EIA provide discussions relating to natural sources being the primary contributor.

Request 35.9 The EIA lists a number of meteorological factors that influence the formation of ground-level ozone. It indicates that the conditions are sufficient for the formation of ozone in the summer period. However, it fails to assess whether or not these conditions are conducive to the formation of ozone in the spring (particularly late-spring) period. Please provide this analysis.

Response 35.9 A review of maximum temperatures for the year, based on climate data from Fort McMurray (1951 to 1980), indicates:

Month	Mean Daily Maximum
March	-2.2°C
April	-8.7°C
May	16.9°C
June	21.0°C
July	23.1°C
August	21.4°C
September	14.8°C
October	8.6°C
November	- 3.5°C

Based on the mean daily maximums, daily maximum temperatures exceed 20°C only in June, July and August. A detailed review of somewhat dated (1957 to 1967) but still relevant temperature data for Fort McMurray indicates the number of hours per year that temperatures exceed 26°C for each month:

May	6 hours
June	12 hours
July	40 hours
August	20 hours
September	1 hour

For all the other months, the temperatures did not exceed 26°C. Based on these temperatures, we conclude that conditions are not conducive to the formation of ozone in March, April or even the beginning of May. Stating that these temperatures are 'not conducive' does not imply that we cannot get high temperatures during the spring. (The overall maximum for April is 30.2°C, based on 37 years of observations.)

Request 35.10 Specifically, present information on the occurrence of moderately high ozone concentrations (i.e. >40 ppb) and the following contributing factors at the AEP Fort McMurray station:

- Temperature
- Mixing depth
- Wind speed
- Wind direction
- Time of year (month)
- Ambient NO_x concentrations

Response 35.10 See Section 7.3 (Ozone Formation) in the Project Update.

Request 35.11 Section E2.8 notes that there is potential for the photochemical production of ozone during limited periods in the summer from existing and Project-related emissions. There is not only the potential but evidence that it is happening at existing (baseline) levels of emissions.

Response 35.11 A review of the data cannot provide conclusive evidence that photochemical production is or is not happening. We contend that there is a potential for photochemical production based on existing conditions. Shell is participating in the ongoing ozone modeling study for the region.

Request 35.12 The comparison between ozone generation and concentrations in the Fort McMurray region with those in Edmonton and Calgary presented in Section F2.4.4 is not valid. There are a number of very different conditions that would make the comparison invalid and questionable. (i.e. urban vs. rural, dispersed vs. point sources, and NO_x/VOC ratios).

Response 35.12 We believe there is validity as both regions will be sources of NO_x and VOC. However, the VOC speciation will likely differ between the two regions. For both regions, the NO_x and VOC emissions will be over a wide area. The main conclusion based on our review is that the similarities of emissions allow us to extrapolate the modeling predictions for the urban regions to the oil sands region. This allows us to conclude that there is a potential for photochemical production as a result of precursor emissions in the oil sands region.

Request 35.13 The conclusion (pg. F-2) that emissions from the Project (under the CEA scenario) would still allow the 82 ppb. guideline to be achieved contradicts other statements made in the EIA that the additional emissions would likely result in exceedances of the hourly ozone guideline. It is also not supported by the conclusions in the ozone modelling report.

Response 35.13 The comment on page F2-20 of EIA Volume 4 concludes that there is the potential for ozone concentrations to exceed the 82 ppb guideline.

Request 35.14 Regional ozone concentrations are particularly sensitive to the total NO_x emissions into the region. It is well established in the literature that the formation of ground-level ozone is related to the VOC/NO_x ratio in addition to the required meteorological conditions. At high VOC to NO_x ratios (i.e. 12), ozone forms freely. Any situation where the ratio is over 6 is considered to be NO_x limited. The estimated VOC/NO_x ratio for the Athabasca Oil Sands region is extremely high (>12).

Response 35.14 The VOC and NO_x ratios based on the THC and NO_x emissions given in the EIA are as follows:

EIA Volume 2, Table D2-1:	43.9/77.8 = 0.56
EIA Volume 4, Table F2-1:	50/110 = 0.45
EIA Volume 4, Table G2-1:	58/195 = 0.39

Based on the VOC emission rates provided in Suncor's Millennium EIA, we have the following VOC and NO_x emission ratios:

RSA Baseline: 182/102 = 1.8
RSA CEA: 365/224 = 1.6

These values only include anthropogenic sources and biogenic emissions for VOCs, which are likely to be significant given warm temperatures during the growing season.

Question No. 2.1.5 (1)

Shell No. OSEC 36

Issue **Acidification - Increased Acid Loading and Acidification**

Request The Oil Sands Environmental Coalition is concerned that emissions of acid precursors (i.e. SO_2 and NO_x) from the Project, in conjunction with existing and predicted emissions from other sources in the region, will have an adverse impact on regional ecosystems, especially those that are acid sensitive. The addition of more acid forming emissions into the region is predicted to result in increased levels of acid deposition and an increase in the area affected.

36.1 The EIA (pg. E2-46) indicates that the baseline conditions are such that the Potential Acid Input (PAI) is predicted to be in excess of the interim critical load over an area of approximately 1,200 km^2, and that the Muskeg Mine emissions would increase this to over 1,500 km^2.

Response 36.1 As indicated in the response to OSEC 7.2, the area under the interim critical loading of 0.25 keq H^+/ha/a is predicted to increase from 1,500 to 1,800 km^2. The 0.25 loading has been designed to protect sensitive mineral soils and lakes from acidification.

Request 36.2 The EIA (pg. E2-46) makes a comparison between the area (in km^2) where the PAI values are expected to be in excess of the interim critical load and the area of the 1° x 1° modelling (approximately 6,600 km^2).

Please clarify the basis for this comparison. Why was the Regional Study Area not used (10,514 km^2)?

Response 36.2 We understood that the Target Loading Subgroup intended the critical load to be applied on a larger scale of about 1° by 1°, not on a local "hot spot" scale. Therefore, the comparison was expressed in this manner.

Request 36.3 Under the combined CEA scenario (i.e. baseline + approved + Project) the area with excess acid loading increases substantially to approximately 2,500 km^2, this represents about 24% of the RSA. The predicted increase constitutes over a 66% increase in the area affected by excess PAI (i.e. the PAI values are predicted to be in excess of the interim critical load) from 1, 500 km^2 (or 1,200 km^2) to 2,500 km^2. This does not even include all of the potential SO_2 emissions that Syncrude could potentially emit if they were to increase production to the level that they are approved for. The Footnote to table F2-1 notes that Syncrude's SO_2 emissions could go as high as 220 t/d. This should have been included in the forecast.

Why was a lower emission level used for Syncrude's potential emission forecast?

Response 36.3 We believed that the use of the 197 t/d value for Syncrude was representative of annual emissions from Syncrude and that the results presented provide a representative indication of predicted changes.

See also the response to OSEC 23.3.

Request 36.4 The RELAD model used to provide an estimate of the total acid input to an area provides an average loading for an $1^{\circ} \times 1^{\circ}$ area. The Regional Study Area occupies more than 2 such grid cells.

How does this compare with the average PAI predicted by the CALPUFF for the same $1^{\circ} \times 1^{\circ}$ cell?

Response 36.4 As indicated in EIA Volume 2, Table D2-23, the maximum RELAD predicted PAI values in the northeastern Alberta area are in the 0.05 to 0.10 keq/ha/a range. For the purpose of comparison, the background value is 0.083 keq/ha/a.

Request 36.5 Section E2.8 notes that values in excess of the target load (interim critical load) are predicted in the vicinity of the Project from existing sources. This appears to be true (see Figure D2-18), but the additional emissions from the Project will increase both the area and magnitude of the effect (see Figure E2-9).

Response 36.5 Agreed.

Request 36.6 The comparison between the background deposition and the interim critical load (and other critical loads for less sensitive systems) presented on Page D2-60 is not valid. At current and historic levels of emissions the PAI is predicted to be in excess of the interim critical load for significant areas of the project area, the LSA and the RSA.

Response 36.6 We do not understand the question.

Request 36.7 The EIA (pg. D2-38) makes the assumption that the regional background base cations (i.e. Ca, Mg, & K) for the air flows into the region would be the average of the Fort McMurray and Ft. Chip measured values. This assumption is questionable.

Response 36.7 The estimation of base cations was also identified as a weakness of the provincial scale RELAD modeling. Hopefully, the re-designed Wood Buffalo monitoring program will collect more applicable data to help us get a better understanding of these values.

Question No. 2.1.5 (7)

Shell No. OSEC 37

Issue **Acidification - Increases in Regional Emissions**

Request

OSEC is also concerned about the long-range transport and deposition of acidifying emissions outside of the defined region. There is a concern about the contribution of this and other oil sands projects on acid deposition in Saskatchewan.

A large portion of the acid forming gases from sources in the Athabasca Oil Sands region are transported out of the region and are deposited in areas down wind, including Saskatchewan. It is not clear from the EIA what percentage of the emissions of acid forming gases are transported outside of the region (i.e. outside of Alberta) and deposited in other jurisdictions. Recent analysis by Environment Canada has indicated that as much as 70% of the acid gases are transported outside of the Province.

Please provide an estimate of the acid gases transported out of the region.

Response

Only NO_x emissions are produced by the Muskeg River Mine Project. These emissions are locally dispersed and are not transported out of the Regional Study Area.

Question No. 2.1.6 (8)

Shell No. OSEC 38

Issue **Hazardous Air Pollutants – Increased Risk to Human and Animal Health**

Request

The Oil Sands Environmental Coalition is concerned that emissions of HAPs and fine particulates from the Project, in conjunction with existing and predicted emissions from other sources, will result in increased ambient concentrations and exposure of humans and other animals to these substances. This would result in increased risk and increased health impacts.

38.1 The EIA underestimated the carcinogenicity of diesel emissions as it does not consider 3-nitrobenzanthrone. The October 1997 issue of New Scientist reports that 3-nitrobenzanthrone, a component of diesel exhaust had the highest ever score for carcinogenicity according to the salmonella test. 3-nitrobenzanthrone was not included in Shells HAPs assessment of carcinogenic substances. Given the volume of diesel burned on the Project site, the assessment should include this substance.

Response

38.1 The discovery of 3-nitrobenzanthrone in diesel exhaust occurred very recently. Therefore, standard diesel characterizations used in air quality modeling have not yet incorporated this chemical. However, nitro PAHs, a related group of chemicals, were recognized as being important for human health. Therefore, 1-nitropyrene was included in air quality modeling as a surrogate for all nitro PAHs.

The researchers cited in the New Scientist article suggest that 3-nitrobenzanthrone is a minor component of diesel exhaust particles (0.6 to 6.6 micrograms/gram of particulate matter released from diesel engines). Based on this and the estimated PM_{10} emission of 476 kg/d, the estimated 3-nitrobenzanthrone emission rate is 3.1E-3 kg/d. This emission rate is similar to that of chrysene (see EIA Volume 3, Part 1, Table E2-2). Maximum ambient hourly average chrysene concentrations given in Table E2-18 are as follows:

Project Area	5.5E-4 $\mu g/m^3$ or 0.55 pg/m^3
Fort McKay	1.5E-4 $\mu g/m^3$ or 0.15 pg/m^3
Fort McMurray	6.5E-5 $\mu g/m^3$ or 0.065 pg/m^3
Fort Chipewyan	4E-4 $\mu g/m^3$ or 0.04 pg/m^3

Ambient 3-nitrobenzanthrone concentrations are expected to be similar. For the purposes of comparison, the ambient 3-nitrobenzanthrone concentrations in the central Tokyo area are 5.2 to 11.5 pg/m^3.

Currently, there is little data available to evaluate the potential health risks associated with 3-nitrobenzanthrone

Request 38.2 Increased regional concentrations of hazardous air pollutants will result in an increased risk to human health. OSEC is aware that the level of THC emissions associated with existing oil sands tailings ponds has been significantly underestimated by as much as 2 orders of magnitude in the past.

Please discuss the implications of the recent tailings pond VOC monitoring information from Suncor on the project and on the regional emissions inventory.

Response 38.2 See Section 7.4 (Volatile Organic Compound Emissions) in the Project Update.

Request 38.3 Exposure ratios for recreational activity for carcinogens arsenic and beryllium are listed as 3.5 and 1.5 respectively. The EIA states that exposure ratios greater than 1 pose a potential concern and require further scrutiny. The assessment states that the naturally elevated concentrations of the above parameters in the Muskeg River are considered acceptable for drinking water purposes (Volume 3, Part 1, E12-26).

Will the project result in any incremental increase in these compounds?

Response 38.3 The project will not result in any incremental increase in arsenic and beryllium concentrations. Exposure ratios for the recreational scenario for these chemicals are based on current baseline levels of arsenic and beryllium in the Muskeg and Athabasca rivers. The background levels of these chemicals in these rivers are within the range of natural background levels reported for Canadian rivers and are less than Canadian and American drinking water guidelines (see EIA Volume 3, Part 1, Page E12-26). Therefore, the marginal exceedances of 1.5 and 3.5 are a function of the conservativeness of the assessment, and it is likely that risks are considerably lower and acceptable.

Question No. 2.1.7 (9)

Shell No. OSEC 39

Issue **Greenhouse Gases - Increase in Shell's Net Corporate GHG Emission**

Request

The Oil Sands Environmental Coalition is concerned that increases in GHG emissions will result in a substantial overall net increase in Shell's Greenhouse Gas emissions which will impair Canada's ability to meet legally binding commitments that were made in Kyoto in December 1997.

39.1 The application does not explain how the Muskeg River project will affect Shell's corporate GHG emissions. Estimated greenhouse gas emissions due to the Muskeg River Mine Project total 2.04 Mt/year (5,602 t/d - pg. E2-56). While GHG emissions associated with bitumen upgrading will be lower on a per unit basis compared to conventional oil sands upgrading this is not an equitable comparison.

Please discuss how Shell intends to 'offset' this increase in GHG emissions internally or externally to the company. Explain in detail how Shell will accommodate the increase in GHG emissions associated with the Muskeg River Mine.

Response

39.1 Shell's commitment with respect to the Voluntary Climate Challenge and Registry Program has been to achieve stabilization of Shell Canada's CO_2 and total greenhouse gas emissions at 1990 levels by the year 2000 based on the 1994 level of business activity. This has led to continuous improvement in the energy efficiency of Shell's oil and gas production facilities as well as improvements in energy efficiency in the refining and manufacture of oil products. A copy of Shell's 1997 Action Plan Update for the Voluntary Climate Challenge and Registry Program is included in Appendix B of this Supplementary Information document.

Shell believes that the oil sands will provide Canada with a secure source of affordable energy supply for the next 20 to 30 years, in the face of declining conventional reserves. Athabasca oil sands are competing with imported crudes in the North American market. The CO_2 associated with the production of 150,000 bbl/d of synthetic crude from the Athabasca oil sands is less than the CO_2 produced from the partial upgrading and transportation of Venezuelan crude to North America, which is the fastest growing alternative.

The Muskeg River Mine Project will increase the overall greenhouse gas emissions for Shell as a result of the increase in Shell's production. Shell is committed to continuously improve the energy intensity of the proposed bitumen production facility and the proposed Scotford Upgrader facility in an effort to reduce greenhouse gas emissions. Targets will be set for these facilities and incorporated into Shell's commitment to the Voluntary Challenge Program. In addition, the Shell oil sands facilities will be compared with imported crudes on a full cycle basis to ensure that the CO_2 associated with the production, shipping, and refining of oil sands products is competitive with imported crudes.

Request

39.2 The EIA does not provide adequate inventory of GHG emission sources. It is not clear how Shell has calculated GHG emissions for the Project. It appears that important fugitive emission sources such as the tailings impoundment and the mine face have not been factored into the totals.

Please provide a detailed GHG emission inventory for the project. Explain how GHG emissions will change over the life of the project.

Response 39.2 The major sources of greenhouse gas emissions for the project were considered in the evaluation presented in EIA Volume 3, Part 1. This included emissions from mobile sources in the mine, such as trucks and shovels (Table E2-5), and emissions from stationary equipment, such as fired heaters, boilers and flares (Table E2-9).

The fugitive C1-C3 emissions resulting from mine surface and tailings have been considered (see EIA Volume 3, Part 1 Table E2-6 and E2-12). All C1 to C3 emissions for the mine surface and tailings were considered as methane. This is considered a worse-case scenario and totals 1.348 t/d of CH_4. This amount was converted to a CO_2 equivalent which is roughly 34 t/d. This figure is presented in Section E2.7.1 as 34 t/d of CH_4 and should read as 34 t/d of equivalent CO_2 due to fugitive C1 to C3 emissions.

In addition, CO_2 equivalent emissions from purchased electricity were included (see EIA Volume 3, Part 1, E2.7.1) and assumes that the purchased power is coming from mostly coal-fired generating facilities.

Emissions from the project are conservative and are expected to decrease over time as improvements in extraction technology, mining equipment and other energy improvements are likely implemented.

Question No. **2.2.1 (10)**

Shell No. **OSEC 40**

Issue **Water Resources - Deficiencies and Errors in the EIA**

Request The Oil Sands Environmental Coalition is concerned that there are a number of deficiencies in the data for aquatic ecosystems that limit the assessment of the impacts in some areas.

40.1 The EIA predicts minor effects on fish habitat for the forage fish guild as a result of the project (E6-31). Considering the uncertainty with habitat information, further baseline data is needed on this guild to ensure that the effects are as predicted.

What other baseline information was used or is available?

Response 40.1 Baseline data that were used to describe the forage guild and their habitat are presented in a number of studies, including R.L.&L. 1989, Golder 1996a, Golder 1996b.

As part of the OSLO program, fish surveys of the Muskeg River were conducted in all seasons (R.L.&L. 1989). A sub-set of these sites was resampled in spring 1995 for the Aurora EIA (Golder 1996b). Surveys were also conducted in the spring, summer and fall of 1997 for the Muskeg River Mine Project (Golder 1997). All of these surveys involved forage fish species and determining species composition and relative abundance.

The RAMP program will include further surveys of forage fish in the Muskeg River.

Request 40.2 The proponent suggests that Mills Creek is very small and would not support fish other than small forage species (E6-15). Although no fish have been documented in Mills Creek the baseline data is limited and the application notes that the habitat is suitable for forage fish. In addition the proponent notes that increased flows during 2020 may affect forage fish (E6-20) (E6-30?). The same section notes that wetland areas and vegetation throughout the area would provide cover for forage fish.

What monitoring or collection of additional baseline data does Shell plan to conduct?

Response 40.2 Mills Creek was sampled in fall 1996 with a backpack electrofisher (Golder 1997). No fish were captured or observed. The creek was also surveyed in fall 1997 with minnow traps. No fish were captured in 1997 (Golder 1998).

Mills Creek will be resurveyed in 1998 to confirm that fish do not use the creek.

Request 40.3 The proponent predicts that there will be no acute or chronic toxicity exceedances (E6-34). However, when discussing certainty on the same Page the proponent notes that "there are no data on the effects of CT water on fish health parameters", and notes that this limits the level of certainty.

Please describe how studies on the potential effects of CT water on fish health will be addressed before the project proceeds.

Response 40.3 Shell, in conjunction with Suncor and Syncrude, will conduct studies on the potential effects of CT water on fish health. These studies will be conducted before the project is operational, to ensure that the results can be incorporated into mitigation and future monitoring plans, if necessary. These studies will include three elements:

- laboratory exposures of fish to CT water (i.e., fish health studies that will include an analysis of tissue residues in fish)
- chemical characterization of CT water used for the tests
- toxicity testing at different trophic levels

Laboratory Exposures of Fish to CT Water:

The overall approach would be very similar in design to the studies already carried out on Tar Island Dyke water and upgrader outfall wastewater from Suncor's Lease 86/17 operation (HydroQual 1996a, 1996b). Studies would include fish health and challenge tests, which are designed to measure potential effects on the general health and condition of fish following prolonged exposure to wastewaters. The study design includes exposures of about one month and a dilution series representative of concentrations predicted to occur in the receiving environment. The following fish health indicators will be examined:

- survival and growth of rainbow trout juveniles and sac fry (i.e., fry transition from sac to swim-up phase) and walleye juveniles (if available)

- suborganismal indicators, including mixed function oxidases, blood chemistry, hematology and DNA adducts

- whole organism indicators, including liver size, fat content, condition factor, growth, gross pathology, histopathology, embryo survival, embryo deformities, swimming stamina and resistance to bacterial infection

- tissue analysis for metals and PAHs (whole fish)

Chemical Characterization of Wastewaters:

In conjunction with the fish health studies, a representative number of samples of CT water will be submitted for analyses of oil sands related parameters and routine water quality parameters. The analyses will be comparable to existing information on CT water chemistry.

Trophic Level Toxicity Testing:

Samples of the CT waters collected for the fish health studies will be tested as follows:

- bacterial luminescence (Microtox)
- algal growth inhibition
- survival of *Daphnia magna*
- survival and reproduction of *Ceriodaphnia dubia*
- survival and growth of fathead minnows
- survival of rainbow trout

The chemistry, fish health data and toxicity test information will be interpreted together. The complete data set will be evaluated for consistency (i.e., the chemistry, toxicity and health data should provide complimentary, not contradictory information). The new data will also be added to the existing chemistry and toxicity data on CT water to enhance the existing information on the potential for environmental impacts from CT water.

Question No. **2.2.2 (1)**

Shell No. **OSEC 41**

Issue **Hydrogeology - Basal Aquifer Depressurization**

Request The Oil Sands Environmental Coalition is concerned that basal aquifer de-pressurization and mining activity will result in significant short-term and long-term impacts on groundwater flow patterns and on surface water bodies.

41.1 Basal aquifer depressurization is expected to result in seepage from Kearl Lake. The application notes that the seepage rate may be as high as 3% of annual precipitation. The combined affect of other oil sands developments resulted in a maximum seepage of 14% of mean annual precipitation. Recovery of the Basal aquifer is likely to take up to 30 years after closure of the Shell Muskeg River Mine.

What impact could this increased rate of seepage have on seasonal lake levels and lake health particularly if drought conditions are experienced in the next 20 years?

Response 41.1 This issue is discussed in detail in the response to DFO 39.

The Muskeg River Mine Project and Shell's Lease 13 East Project will result in negligible impacts on the Kearl Lake water balance, including inflows, water levels and outflow. The influence of Aurora South, Shell Lease 13 East and Mobil's Kearl Oil Sands Project on Kearl Lake are discussed in EIA Volume 4, Page G3-2.

Request 41.2 The report needs to discuss possible mitigation of this effect. Will Shell monitor Kearl Lake over time?

Response 41.2 Although measurable impacts on Kearl Lake or nearby wetlands are not expected, this conclusion will be verified by groundwater monitoring adjacent to Kearl Lake, between the lake and the mine pit. The detailed groundwater program has not been designed. However, the conceptual design is presented in the response to DFO 45.

Request 41.3 Will Shell monitor other lakes in the area?

Response 41.3 No effects are expected on McClelland Lake as the lake is beyond the subcrop of the basal aquifer (see EIA Volume 3, Part 1, Page E3-12). Isadore's Lake level will be monitored throughout the project's life.

Request 41.4 CT pore-water from reclaimed overburden or sand cap materials will result in degraded groundwater quality.

Response 41.4 Mine-related seepage and its effect on the various groundwater systems is discussed in detail in EIA Volume 3, Part 1, Section E3. Basal aquifer water quality is poor to begin with and would not be materially degraded by CT porewater from reclaimed overburden or sand cap materials.

Question No. **2.2.3 (12)**

Shell No. **OSEC 42**

Issue **Surficial Hydrology - Altered Surface Water Patterns**

Request 42.1 Existing oil sands operations have very little experience in establishing landscapes with viable drainage systems. According to the reclamation plan and hydrology assessment, Shell proposes to increase the total area of streams, wetlands, shallow lakes and end-pit lake by 25% in the project area. This proposed increase in end-pit lake surface water is of concern to OSEC.

What options have been considered to reduce the total area of water bodies, particularly the end-pit lake?

Response 42.1 The end-pit lake is beneficial to hydrological effects in the reclaimed landscape. The Muskeg River Mine project area is classified as lowland area with high groundwater table or standing water in natural conditions. It has a large surface storage capacity, reducing runoff peaks and increasing evapotranspiration. The end-pit lake in the final landscape helps restore this surface storage capacity. Therefore, the resulting runoff release from the closure drainage systems has minor effects on the Muskeg River flows, as shown in EIA Volume 3, Part 1, Section E4.7.3, Table E4-19.

If the final landscape did not include the end-pit lake, this would result in higher hydrologic impacts for the post-closure conditions and larger increases in the Muskeg River flows than under the existing plan.

Request 42.2 The proposed Muskeg River Mine development, and other oil sands developments, will result in losses of large areas of natural wetlands and natural open water areas. These losses will exist for approximately 20 years before being replaced by larger areas of non-natural open water.

What reclamation scenarios have been considered that more closely emulates the existing mix of wetlands and other open water areas?

Response 42.2 Shell proposes a reclamation plan that largely represents a shift from a predominantly wetlands environment to an upland environment. However, the mix of reclamation wetlands will include the end-pit lake, constructed wetlands (emulating a shallow open water-marsh complex) and shrubby swamp as part of the drainage system. This reclamation scenario was developed to fulfill the end land use objectives proposed by the Fort McMurray-Athabasca Oil Sands Sub-Regional Integrated Plan (IRP).

Shell is participating in the Wetlands Working Group for the oil sands region. The committee is examining the feasibility and potential functions of reconstructed wetlands. This information will assist Shell in designing the details of the reclaimed landscape.

Request 42.3 The Shell Muskeg River Mine and other oil sands mine developments will contribute to increased stream flow sediment in the Muskeg River (2% to 13%).

Discuss potential mitigation to reduce predicted sediment from the proposed Shell Muskeg River Mine.

Response 42.3 Mitigative measures for minimizing sediment inflows to Muskeg River that might result from the various project activities are described in EIA Volume 3, Part 1, Section E4.4.1. The residual impacts on streamflow sediment concentrations will be associated with flow increases in the Muskeg River.

The Muskeg River Mine Project will result in negligible increases in the Muskeg River streamflow sediment concentrations during construction and operation and after closure. During the short-term end-pit lake management period, the project will result in an average increase of TSS in the Muskeg River from 9.5 to 10.3 mg/L. This level of increase is considered small, and no mitigative measure is required.

A change in sediment of up to 2 mg/L is unlikely to cause any effects on benthic invertebrates or other aquatic organisms.

Question No. 2.2.4 (13)

Shell No. OSEC 43

Issue **Surface Water Quality – Decreased Quality in the Muskeg River and Jackpine Creek**

Request

The Oil Sands Environmental Coalition is concerned that Shell's operations and resultant restructuring of the drainage regime will contribute to increased erosion near the Muskeg River and Jackpine Creek.

43.1 It is unclear from the application and EIA if the 100 metre setback from the Muskeg River and Jackpine Creek is from the water's edge or from the escarpment.

Please clarify this.

Response

43.1 Shell has assumed a minimum of 100 m of undisturbed forest from the Muskeg River and Jackpine Creek to the escarpment. Because of the meandering nature of the Muskeg River, the actual distance might vary to over 250 m (see EIA Volume 3, Part 1, Section E6).

Request

43.2 It is unclear from Figure E4-8 if the flood level waters extend into the closed-circuit operations areas. Also, the flood levels discussed are for 1:100 year flood conditions. Given fluctuations in the weather conditions and the recent increase in extreme weather events (and floods) the 1:100 year flood levels may not be conservative enough.

What would the contours look like for a 1:150 or 1:200 year flood? What kinds of protections would need to built into the project? How would these waters be handled if they did flood?

Response

43.2 The flood protection standard is 100 years for all municipal developments in Alberta, including Calgary and Edmonton. The 100-year flood design standard selected for the Muskeg River Project is appropriate.

Freeboard allowance above the 100-year flood levels along the road embankment will be provided to increase the reliability of the 100-year flood protection (see EIA Volume 3, Part 1, Page E4-13, Figure E4-8).

During operations, the mine pits will be protected against flooding by road embankments built alongside the mine pits. In the unlikely event that flood events with higher return periods do occur during the mine life, emergency flood protection measures, such as raising embankment heights and sand bagging, will be provided to minimize any potential flood inflows to the mine pits. Potential flooding would only occur at pit cells 2 and 3. Any flood water in contact with the oil sands would be pumped to the recycle ponds for internal recycle.

Request The Oil Sands Environmental Coalition is further concerned that the impacts of the Project on surface water quality and flows may be under-predicted.

43.3 The inputs used in the hydrological model in the EIA may have poor predictive value in the short-medium term. The use of 42 years of climate data (pg. E4-25) may have produce a rolling average effect on the hydrological model. The last 15 years have included the hottest years on record.

Would the model predictions be affected if only the last 15 years data were used?

Response 43.3 The longer the simulation period, the more reliable the hydrologic simulation results that can be used to produce more reliable flow statistics (low, mean and high flow parameters).

If a shorter period (e.g., 15 years) of climatic data were used, the modeling results would be less reliable in characterizing the flow variation, including low, mean and high flows, and the flow parameters derived based on the 15 years of data would be less accurate than those based on the 43 years of data.

Request 43.4 The table on Page E4-27 indicates very low water levels in the 1980's; however the projections to 2030 do not predict any periods of very low water levels.

Please discuss the implications of this.

Response 43.4 The effects on Isadore's Lake water levels in 2030 are presented in EIA Volume 3, Part 1, Table E4-21, including 10%, 50% and 90% exceedance statistics. These effects are discussed on Page E4-53. The maximum reduction in the lake water levels is estimated to be 5.3 cm, based on the long-term (43 years) hydrologic simulation results. This compares with a 2.8 cm reduction in lake water levels with a 90% probability of exceedance. The maximum reduction in lake water levels (5.3 cm) represents about 3% reduction in average lake depth (1.55 m). This level of reduction is considered small.

Question No. **2.2.5 (14)**

Shell No. **OSEC 44**

Issue **Aquatic Resources - Ecosystems and Wetlands Adverse Effects of Project**

Request The Oil Sands Environmental Coalition has concerns with the loss of wetlands in the study area.

Of the existing wetland and riparian communities in the project area, 28% will be lost as a result of development. Within the LSA, wetland communities will decrease by 34% while upland communities will increase by 53% (pg. E9-37).

In the project area, 3,076 ha or 46% of wetlands will be lost, a loss of 28.1% of the wetlands in the local study area (LSA) (E10-9).

Patterned fens, which make up 1.9 ha of the LSA and are recognized as being unique and sensitive habitats, will be completely eliminated by the project (E10-11). No plot surveys were done in patterned fens to assess species richness or diversity (E10-21).

44.1 The description of monitoring for Isadore's Lake and the Muskeg River states that monitoring will be done for the years in which the flows are in excess of a specified flows and would be discontinued if no impacts were observed. One of the purposes of any monitoring program is to collect baseline data in the event of surprising or unanticipated events.

What plans does Shell have to continue the monitoring of Isadore's lake and the Muskeg River flows over the long-term?

Response 44.1 The long-term monitoring programs for water flows, quantity and hydrology are presented in Section 7.2 (Monitoring and Research) in the Project Update. See also the response to AEP 35 on Shell's Monitoring Program.

Request 44.2 The application suggests that a delayed warming of the Muskeg River may result due to thermal effects from the proposed end-pit lake.

Provide details on how water release from the end-pit lake would be adjusted if negative effects are detected.

Response 44.2 Thermal effects and Shell's proposed mitigation plans to ensure no negative effects to fish or fish habitat are presented in Section 7.2 (Monitoring and Research) of the Project Update. See also the response to DFO 33.

Request 44.3 There likely be a simplification of the wetlands ecosystem in the area as a result of the Project. The application notes that eleven community types have been chosen as appropriate for establishment on reclaimed landscapes after mine closure. Three of these communities are considered wetlands: ponds; shallow water; and shrub complexes (riparian habitats). Of these three only the riparian habitats would be expected to have significant species richness or diversity. The number of wetland types found on reclaimed lands drops from 9 pre-disturbance to 3 for the reclaimed landscape (310-22). Compared to the existing wetland diversity this is a significant reduction.

There is a high degree of uncertainty in some of the impact analyses of aquatic ecosystems and wetlands.

Fens and bogs in the Project Area will be destroyed or negatively impacted by the Project.

There is a high potential for impacts on fen systems due to reduced through-flow as a result of aquifer drawdown. Fens have been identified as ecologically significant areas sensitive to disturbance. The application notes that the direction magnitude of this impact is undetermined and therefore no degree of concern can be assigned.

What further work does Shell plan to do to describe the potential impact to fen systems?

Response 44.3 The effects of aquifer drawdown on wetlands, including fens, have been quantified in EIA Volume 3, Part 1, Table E10-2. Further assessment of the effects of aquifer drawdown is described in Section E10.6.2, Page E10-14. The drawdown effect is restricted to a 1.5 km buffer around the mine development area. This area was included in the residual impact assessment (Table E10-6) in which the impacts to all fens are described as negative in direction, not undetermined.

Request 44.4 The EIA notes that fens and bogs make up about 3,070 ha of the project area. These will be completely eliminated from the Project area. The application notes that these fens and bogs will be replaced by 119 ha of marsh wetlands and 88 ha of associated ponds (pg. E16-17).

Wetlands occupy 684,449 ha (or 65% of the RSA), of which 51,490 ha are already affected by current or approved projects. The Muskeg River Mine project is predicted to directly affect an additional 3,344 ha of wetlands. This will result in a total disturbance of wetlands of 54,834 ha (or 5.2% of the RSA). The highest impact will be to wooded fens and bogs. Fens and bogs will not be replaced in the reclamation landscape so this loss must be considered permanent.

Response 44.4 The Wetlands Working Group, which is funded by Shell, Suncor and Syncrude, is examining the design feasibility and function of reconstructed wetlands.

Request 44.5 There are a number of places throughout the EIA where the area disturbed is presented inconsistently. The total area of disturbance cited on Page F10-2 is 88,397 ha. This also differed from the values provided in Tables F1-4, G1-2, and G7-1. Table G7-1 has an addition error in it. The area disturbed by the Muskeg River Mine is not included in the total. There also appears to be some disturbances left off of this table This would include other anticipated developments in the region such as municipal developments, linear disturbances, forestry, etc. We have attached a suggested revised table as Appendix II to this report.

Please correct the errors in the area disturbed and provide revised values and tables.

Response 44.5 Differences in tables are attributed to differences in the types of disturbances affecting terrestrial resources. For example, forestry disturbances only affect vegetation and wetland resources, not soils and terrain. The total disturbances considered for the Terrestrial Assessment for all projects are listed in EIA Volume 4, Table F7-1.

Request 44.6 Table G1-2 presents only the information for the planned developments. It does not include the Muskeg River Mine, which is included in Table F1-4. Table G1-2 should include the Muskeg River Mine Project, as well as any other disturbances that are expected in the region from other developments (i.e. municipalities, linear disturbances, forestry, etc.). Table G1-2 should also have a line for the current and approved developments.

Response 44.6 Shell appreciates OSEC's suggestions. The disturbances considered for the terrestrial assessment are listed in EIA Volume 4, Table F7-1. In addition, forestry operations were considered in the vegetation and wetlands cumulative effects assessment.

Assumptions that were applied in estimating disturbance areas are discussed in Sections F1.4.6 (municipalities), F1.4.8 (forestry) and F1.4.9 (linear disturbances).

The limitations in obtaining information on planning activities for these latter activities governed the level of assessment possible in the EIA.

Request 44.7 The application notes that the distribution of patterned fens in the RSA is difficult to determine due to the lack of detailed mapping and field observations (pg. F10-5). The estimate is given that there are a total of 3,700 ha of fens in the Central Mixedwood Natural Subregion (pg. F10-5). Fens will not be replaced in the reclamation landscape so their loss, other than in the far future, is permanent. For all intents and purposes this should be considered a permanent loss.

What work, in the form of detailed studies, will be done in the RSA to identify the extent of patterned fens so that a more accurate assessment of the cumulative impact on fens can be made?

Response 44.7 In all wetlands impact classification tables, impacts to fens and bogs are considered irreversible or permanent (see Table E10-6 in EIA Volume 3, Part 1 and Tables F10-6 and G10-3 in EIA Volume 4).

Shell does not intend to conduct additional studies or assessments of patterned fens in the RSA. Wetlands were identified through aerial surveys and aerial photograph interpretation for Syncrude and Suncor to further delineate or refine the regional map. Wooded peatlands were divided into Wet Closed Coniferous (Sb Dom.), Wet Open Coniferous, Bog (Sphagnum Dom.), Bog (Shrub Dom.) and Shrubby Fen.

Linda Halsey states that the University of Alberta is continuing to map wetlands within the Regional Study Area (pers comm. June 3, 1998). This classification includes the delineation of fens. When complete, this information will add further detail to the regional database on fens.

Request 44.8 The application states that the increase in open water from ponds and wetlands created in the reclaimed landscape will be a benefit to wildlife. It is our understanding that the CT water will initially flow through these ponds and wetlands. How will CT water affect the productivity of these ponds and wetlands as well as vegetation and animal health?

Response 44.8 The landscape will be reclaimed in phases over several years. CT water will be pumped from the CT deposits and a thick capping layer of reclamation soils will be applied to the CT deposits. As the landscape stabilizes, vegetation communities will become established, and CT water will flow through the ponds and wetlands on the reclaimed landscape. The volume of CT water seepage will decrease with time, so that by the time this landscape provides suitable foraging habitat for wildlife species, CT water levels should be low.

In the assessment of wildlife exposures on the reclaimed landscape in the far future (see EIA Volume 3, Part 1, Key Question W-7, Page E11-98), the drinking water source for wildlife was assumed to consist of metal and PAH concentrations representative of undiluted sand seepages. The chemistry of these seepages is a reasonable reflection of diluted CT water in the far future when wildlife are likely to occupy the area. In addition, the ingestion of terrestrial and aquatic plants and invertebrates from the reclaimed landscape was included in the multi-media exposure assessment. The results of the risk assessment indicated that exposures to metals and PAHs in this seepage water would result in negligible impacts to wildlife. However, because of the uncertainty about the potential toxic effects of naphthenic acids (a component of CT water) the impact was classified as low, and further research and monitoring are being conducted.

Suncor's recent studies of the effects of tailings seepage water on wildlife and aquatic ecosystems have indicated no effects on wildlife. However, Shell recognizes that uncertainties exist about the potential effects of seepage water from consolidated tailings. Shell is working with other members of the oil sands industry to reduce this uncertainty and find ways to avoid or mitigate any effects. Currently, Shell is participating in CONRAD along with Syncrude and Suncor on research on the effects of CT on terrestrial and aquatic landscapes and vegetation and wildlife health. In addition, Shell will monitor the quality of CT release waters from the Muskeg River Mine Project.

Request 44.9 The mean open water level of Isadore's Lake is predicted to be reduced by the Project. The application notes that reductions in the mean open water level of Isadore's Lake may translate to a loss of nutrient inputs (E16-27).

How would the reduction in water levels in Isadore's lake affect the wetland (particularly since one of the KIRs, northern pike, use this lake to breed when water levels allow access)?

Response 44.9 The reduction in lake levels is not expected to affect the northern pike KIR as the water level change is small (see EIA Volume 3, Part 1, Page E6-15 to E6-20).

No effects on pike would be expected, if nutrient inputs to the lake declined. Declines in nutrient levels in the lake could potentially affect vegetation composition and the levels of plankton which are food for juvenile northern pike. However, as the numbers of northern pike that use the lake are low, it is unlikely that either of these features of the lake are limiting to this KIR.

Water quality and vegetative composition of Isadore's Lake will be monitored throughout the life of the project as part of RAMP (see Section 7.2, Monitoring and Research, in the Project Update).

Request 44.10 Changes in water quality and quantity may have a negative effect on wetlands. The application states that the reclaimed landscape will have a greater amount of surface runoff than the pre-development condition as fens and bogs will be replaced with better drained reclamation landscapes (pg. E16-26).

How will this increase in surface water run-off affect the integrity of the remaining wetlands?

Response 44.10 The reclaimed landscapes will be better drained than pre-development landscapes because of the lack of bogs and fens. The closure landscape (see EIA Volume 3, Part 1, Figure E16-6), shows that the reclamation landforms are drained through a series of designed drainage channels, which are integrated into the reclaimed landform as self-sustaining systems. These drainage systems will effectively channel the waters from the reclaimed landforms to major receiving systems, such as the end-pit lake, Muskeg River, Athabasca River and Isadore's Lake. Therefore, the increase in drainage from the reclaimed landscape will not have an impact on the remaining wetlands areas.

Question No. **2.2.5 (15)**

Shell No. **OSEC 45**

Issue **Aquatic Resources - Ecosystems and Wetlands Increased Levels of Acid Deposition**

Request

The Oil Sands Environmental Coalition is concerned that an increase in acidifying emissions and the resulting increase in acid deposition predicted will result in the acidification of wetlands.

45.1 The application and EIA note that predicted potential acid input (PAI) values exceeds interim critical load for the protection of sensitive ecosystems for a significant portion of the local and regional study areas.

Response

45.1 The lakes and watercourses within the PAI contours affected by the NO_x emissions from the Muskeg River Mine Project are well buffered against acidification.

As stated in EIA Volume 4, Section F9, ecosystems that are sensitive to acidic deposition are primarily those located in areas with low buffering capacity, such as peatlands (Treshow 1984). The ecosystems occurring within the interim critical load contours are primarily wooded fens or peatlands. However, studies have not found any trends of peatlands or soil acidification in northeast Alberta (Bovar, 1996a). Shell's contribution to the regional PAI will be minimal, as discussed in Section F-2 (Air).

Saffran and Trew (1996) identified the sensitivity of Alberta lakes to acidifying deposition. Table 45-1 shows the lakes within the project RSA that were identified as highly or moderately sensitive. None of these lakes should be affected by the NO_x concentrations produced from the Muskeg River Mine Project.

Table 45-1: Lakes Highly or Moderately Sensitive to Acidification - Muskeg River Mine Project RSA

Lake Number and Name	Latitude and Longitude	pH	Alkalinity (mg $CaCO_3$/L)
L1 (unnamed)	59°17' 07" 110° 55' 26"	6.40	4.3
L4 (unnamed)	57° 09' 07" 110° 51' 05"	6.44	10.4
L7 (unnamed)	57° 05' 25" 110° 45' 07"	6.67	13.1
L8 (unnamed)	57° 02' 45" 110° 35' 51"	7.00	14.2
Source: Saffran and Trew (1996)			

Request

45.2 Modeled values for annual PAI are predicted to exceed the interim critical load of 0.25 keq/ha/yr. Over significant portions of the study areas. The application notes that the vegetation communities within the 0.25 keq/ha/a isopleth are primarily wooded fens and peatlands (F9-1). There is little information on how wetlands will be affected by this level of long-term acid loading.

Response 45.2 Agreed. There is little research on the long-term effects of PAI on wooded fens and peatlands.

Request 45.3 A reference from Roberts and Reigner (1989) was quoted in the EIA as saying that no trends for peatland or soil acidification in northeastern Alberta have been found. This reference is described as being part of the Syncrude Aurora, but it was not included in the reference section of Volume 2.

Please provide a citation for this reference.

Response 45.3 Roberts, T.L., and H. Regier. 1989. Long term soil acidification monitoring in Alberta from 1981 to 1988. Soil Protection Branch, Waste and Chemicals Division, Alberta Environment, Lethbridge, Alberta, Unpublished Report.

Question No. **2.3.1 (16)**

Shell No. **OSEC 46**

Issue **Terrain and Soils - Adverse Effects**

Request The Oil Sands Environmental Coalition is concerned with the degree and type of terrain modification proposed by the proponent.

46.1 Approximately 40% of the existing terrain within the Project Area will be affected to some degree by the project, mostly in fens and glaciofluvial soils. The application states that in fact the closure landscape will be more diverse than the present landscape and that this increase in diversity is positive. The increased diversity referred to in Table 8-1 consists of conversion from a pre-disturbance terrain made up of bogs, fens, glaciofluvial, and glaciolacustrine terrain to overburden capped CT, sand capped CT, a tailings settling pond, an end-pit lake and overburden disposal areas. The application states that these closure landforms will present "greater relief, varied drainage regimes, and a wider variety of environmental types for vegetation colonization and wildlife habitat" (E8-16).

Response 46.1 This statement is accurate. Reclamation will add more and different terrain types. Sixty percent of the LSA will remain as unaltered or natural terrain types. The greater number of terrain types with more varied slopes and aspects would equate with a more diverse landscape. Similarly, it would appear to introduce the potential for a greater range of ecological niches, setting up a stage for natural vegetation to recolonize in the reclaimed landscape.

Request 46.2 There were no key indicator resources (KIRs) selected for the terrain and soils components of the EIA (pg. E8-1).

Response 46.2 KIRs help to focus an impact assessment when the resource being examined is complex and the subcomponents of the resource respond differently to a development activity. In the Muskeg River Mine Project EIA, the impacts on all terrain and soil types were examined, not on representative units.

Request 46.3 The success of reclamation depends on the presence of a healthy soil flora and fauna. If this community is not successfully established, nutrient cycling and, as a result, vegetation establishment can be inhibited.

How will changes to soil communities be assessed and monitored over the long-term?

Response 46.3 Shell will establish a long-term soil monitoring program for its reclaimed sites. As the final program design has not been completed, the inclusion of soil organisms will be considered.

Request 46.4 The Project is anticipated to result in a decrease in patch size for some landscape units. Creeburn Organic Plain and Boucher Organic Plain, which have been identified as landscape types will have significant losses in area, are also identified as having a decrease in the variability of patch sizes.

Response 46.4 No response required.

Request 46.5 Table E7-2 provides information on the macroterrain units present in the LSA and area and the percentage of each unit predicted to be lost through project development.

Please provide a detailed map to accompany Table E7-2 outlining the geographic distribution of the macroterrain units.

Response 46.5 A detailed map is provided in EIA Volume 2, Section D7, and in the *Ecological Land Classification Baseline Report.*

Request 46.6 Shell identifies the capability of reclaimed soils for forest production as an issue but does not identify capability to support other types of vegetation as an issue. This is particularly important for rare plant communities which may depend on unique soil characteristics.

Response 46.6 The Oil Sands Vegetation Reclamation Committee Report (1998) outlines the vegetation communities that should be re-established on reconstructed soils. Over time, rare plants associated with these vegetation communities are expected to invade the reclaimed landscapes. Shell will establish vegetation monitoring plots on its reclaimed sites.

Request 46.7 The application states that there will be a 404% increase in class 3 soils compared with the pre-development condition (E16-35); an increase of 3,035 ha. However, this section fails to note that there will also be a loss of 70% of the class 2 soils compared to the pre-development condition; a loss of 123 ha.

Response 46.7 These data are presented in EIA Volume 3, Part 1, Table E16-2, Page E16-19.

Question No. 2.3.1 (17)

Shell No. OSEC 47

Issue **Terrain and Soils - Increased Levels of Acid Deposition**

Request The Oil Sands Environmental Coalition is concerned that an increase in acidifying emissions and the resulting increase in acid deposition predicted will result in the acidification of soils.

Soils in the Local Study Area have been assessed as moderately to highly sensitive to acid inputs. The potential acid input (PAI) for the area is predicted to reach 0.55 keq/ha/a. This level would exceed the interim critical loading for sensitive soils, as well as the value suggested for moderately sensitive soils.

47.1 Please provide a map clearly outlining areas of sensitive soils in the region and overlay this with the predicted acid deposition loadings (PAI isopleths).

Response 47.1 Maps will be prepared for review.

Request 47.2 A significant portion of the study areas is predicted to have acid loadings which would exceed the interim critical loads. The EIA notes that for the CEA scenario the predicted to have a total acid loading (PAI) in excess of the interim critical load factor would be approximately 50,000 ha (or 23.8% of the RSA). The area for which the 0.50 keq/ha/a loading factor would be exceeded is approximately 31,500 ha (or 13% of the RSA).

Response 47.2 Shell will work with the Wood Buffalo Environmental Association to ensure that the effects of NO_x emissions, which are the only emissions contributed by the Muskeg River Mine Project, are monitored. See also the response to OSEC 51.1.

Request 47.3 The application notes that mesotrophic fens have high recharge rates that may influence potential acidification by flushing out concentrations of acidic ions and/or replacing mobilized bases with dissolved cations (F8-15). As many of these fens will likely be lost, this could exacerbate the situation.

What impact will the removal of fens from the Project Area have on soil acidification or on the remaining wetlands?

Response 47.3 Fens or organic material have less buffering capacity than mineral soils. Therefore, they permit a proportionally greater flow through of acidic ions. During mine operation, the exposed subsurface materials (i.e., shales) will have a higher buffering capacity than the previously overlying organic deposits associated with fens. Therefore, the removal of fens from the project area would have little effect on soil acidification on the remaining wetlands. Instead, the more basic subsurface materials will increase the buffering capacity to any downstream wetlands.

Following closure, the peat-mineral reclamation soil mix will incorporate these subsurface fractions with pH levels near or slightly less than neutral (7.0). By comparison, while mesotrophic fens are naturally recharged with mobilized bases, their pHs still tend to be closer to 6.0. Therefore, following closure, the removal of fens would have little impact on soil acidification within the LSA as the reclaimed areas would have a higher inherent buffering capacity.

Question No. **2.3.1 (18)**

Shell No. **OSEC 48**

Issue **Terrain and Soils – Productive Wetland Soils**

Request

The Oil Sands Environmental Coalition is concerned that the Muskeg River Mine and reclamation will result in the conversion of wetland soils to low-productivity soils over significant portion of the Project Area.

48.1 The application states that approximately 3,000 ha of soils rated as class 4 and 5, described as non-productive, will be replaced by a soil mixture rated as class 3, low productivity for forestry. The application describes this conversion as a positive development. These soils are non-productive only from the perspective of forestry; wetlands are ecologically highly productive communities

Response

48.1 Currently, there are capability classifications only for forest and agricultural applications in the province and none for wetlands. As requested in the Terms of Reference, the *Land Capability for Forest Ecosystems in the Oil Sands Region* (Leskiw 1996) was used.

Request

48.2 Table E7-2 indicates that there will be an overall loss of 19% in area of the pre-disturbance macroterrain units, with a total of 51% loss in area to the Athabasca Riparian Terrace, Boucher Organic Plain, Creeburn Organic Plain, Jackpine Creek (Organic) Plain, MacKay Upland, and Muskeg River Upland macroterrain units. The losses to the Boucher Organic Plain (65%), the Creeburn Organic Plain (77%), and the MacKay Upland (81%) are particularly large.

Response

48.2 Within the context of the RSA, these losses are relatively small. The Boucher Organic Plain, Creeburn Organic Plain, and MacKay Upland are all included within the Steepbank Organo-Lacustrine Plain, which comprises 275,427 ha (see EIA Volume 4, Table F7-2 and Figure F7-1). The Muskeg River Mine Project will affect 3,429 ha or 4% of this regional macroterrain unit. The total disturbance to this macroterrain unit from project, CEA and RDR developments in the RSA is 32,888 ha (see Table G7-2, page G7-4). This represents a total loss of about 12% of this unit. These three macroterrain units, although unique to the LSA, are not unique within the region.

Question No.	**2.3.2 (19)**
Shell No.	**OSEC 49**
Issue	**Terrestrial Ecosystems - Negative Impacts on Forests**

Request

The Oil Sands Environmental Coalition is concerned that the Project and the reclamation will result in substantial conversion of terrestrial ecosystems.

49.1 Mature and old growth forests are important ecological units. Detailed age-class information is lacking in the EIA for jack pine and white spruce stands in the Project Area.

Please provide more detailed stand age-class information in order to identify mature stands and old-growth stands of white spruce and jack pine in the project and study area.

Response

49.1 There was only one jack pine stand with an age that is defined as old growth. The average age of this stand is 127 years and it occupies an area of 127 ha. More detailed information on stand ages is provided in Appendix I of the *Forestry Baseline Report.*

Request

49.2 The EIA notes that lichen-jack pine forests are found in a number of ecosite phases, and that only small portions meets age class criteria for old-growth forest (E9-13). The application also notes that the area to be cleared does not include the area of old-growth forest; however, if it should be noted that mature stands, younger than the ages used as criteria for old-growth status, have some of the characteristics of old-growth stands and will likely progress towards this if left undisturbed.

Response

49.2 The LSA is within Forest Management Unit A7. The younger stands described would have been proposed logging areas. In addition, few stands meet old growth or climax conditions because of the frequency of fire within the Boreal forest (AEP 1994, *Natural Regions and Subregions of Alberta.* Edmonton, Alberta, Page 13)

Question No.	**2.3.2 (19)**
Shell No.	**OSEC 50**
Issue	**Terrestrial Ecosystems – Negative Impacts on Rare Plants**

Request

50.1 Rare plants and rare plant habitat will be lost in the local study area.

BOVAR and Golder field surveys identified 14 rare plant species at 11 site within the LSA. An additional 12 ecosites totaling 9,046 ha of the LSA were identified as having rare plant potential.

Of the 9,046 ha that have been identified in the local study area as having high rare plant potential 3,757 ha (or 42.5%) will be lost due to project construction and operation (E10-12). The application notes that only 331 ha, or 3% of the area with high rare plant potential will be reclaimed due to the inability to reclaim fens, which make up much of the area of high rare plant potential.

Response 50.1 This is an accurate statement. However, upland habitats will be reclaimed, so that there is the potential to support rare plants. Although fens classified as having a high rare plant potential will not be re-established on reclaimed landscapes, recent data have suggested that marshes support rare plants (e.g., Shipyard Lake marsh system). The constructed wetlands and associated drainages will emulate a marsh system. Therefore, reclamation landscapes (constructed wetlands) might support rare plant habitat in the future.

Request 50.2 The proponent suggests that more detailed field studies are required to improve the analysis of the rare plant ranking system. OSEC suggests that a detailed regional rare plant assessment is also needed.

Response 50.2 A detailed regional rare plant survey is beyond the scope of the EIA. However, a component of the RAMP studies will identify rare plant habitat associated with select wetlands within the RSA. This will not be a rare plant inventory as defined by the Alberta Guidelines (1998). However, all rare plants will be recorded.

Request 50.3 Please clarify whether residents with local knowledge and expertise were contacted for information on rare plant locations.

Response 50.3 All documented information on the LSA was reviewed before field sampling. Residents of Fort McKay were consulted to determine traditional plant locations in the LSA.0

Request 50.4 Please indicate whether the 1995 & 1997 field studies of rare plants were carried out successively over the growing season (i.e. in order to detect species which bloom at different times throughout the season).

Response 50.4 Field surveys were undertaken in July 1997 to maximize identification of rare plants in the area. This time frame is consistent with the phenology of rare plants in the Boreal Forest. Rare plant inventories conducted as part of the Aurora Mine EIA were undertaken in the third week of June and fourth week of July 1995. All rare plant data collected for the area is presented in EIA Volume 3, Part 1, Section E9.

Request 50.5 The potential for the loss of rare plants from the combined developments is associated with the total loss of fens and bogs in the RSA. This amounts to 54,834 ha or 5.2% of the RSA. The application notes that no ecosites with either high or moderate rare plant potential will be re-established on reclamation landscapes (EIA Volume 4, Page F10-6).

Response 50.5 This section only refers to wetlands rare plant potential. However, upland habitats which have the potential to support rare plants, will be reclaimed. See also the response to OSEC 50.1.

Question No.	**2.3.2 (20)**
Shell No.	**OSEC 51**
Issue	**Terrestrial Ecosystems - Adverse Effects on Vegetation by Increased Air Emissions**

Request

The Oil Sands Environmental Coalition is concerned that the increased regional emissions of NO_x will have adversely affect vegetation in the area. This concern is mainly focused on the potential chronic effects of NO_x fumigation on vegetation.

51.1 The EIA predicts that there will be no short-term effects of NO_x on vegetation (E9-23). However, the potential for chronic effects of NO_x vegetation is uncertain as well as the potential for effects of NO_x interactions with other pollutants.

Please discuss the potential for chronic effects from long-term exposure and from effects of NO_x interactions on vegetation.

Response

51.1 High levels of NO_2 are only predicted to occur within the mine development area and vegetation within this area will be cleared. NO_2 concentrations outside of the mining area are not expected to be high enough to cause either short or long-term effects to vegetation.

The Terrestrial Environmental Effects Monitoring (TEEM) program under the Wood Buffalo Environmental Association (WBEA) is being designed to assess the effects of air emissions on vegetation. The WBEA recognizes that the ambient and TEEM components of the program need to be amended to ensure that the programs are compatible and address all relevant emissions, including NO_2. As noted in OSEC 50.2, Shell will work to ensure that NO_2 issues are addressed in the program design. See also the response to AEP 35 on Shell's Monitoring Committee.

Request

51.2 The regional ambient air monitoring program (RAQCC) does not consider NO_x emissions in the site selection criteria. The EIA notes that it may be necessary to amend the sample design to include NO_x.

What actions will Shell take to ensure that NO_x is considered in the site selection of future monitoring stations?

Response

51.2 Shell currently participates in the meetings of the Wood Buffalo Environmental Association (formerly RAQCC) and will become a full member once its mine is in operation.

Shell will ensure that NO_2 concentrations are considered in the ongoing ambient air quality monitoring program. See also the response to AEP 35 on Shell's Monitoring Committee.

Request

51.3 The EIA states that the assessment of the effects of NO_x on vegetation communities is best discussed on an individual project basis. This is an issue that should also be discussed from the perspective of regional effects within the RSA due to the chronic effects on vegetation of long-term exposure to low levels.

Response 51.3 See the response to OSEC 51.2.

Question No. **2.3.2 (20)**

Shell No. **OSEC 52**

Issue **Terrestrial Ecosystems – Adverse Effects on Vegetation from Increased Ozone**

Request The Oil Sands Environmental Coalition is concerned that the predicted increased regional concentration of ozone will adversely affect vegetation in the area. This concern is mainly focused on the potential chronic effects of ozone on vegetation, and includes ozone in combination with other pollutants.

52.1 Ozone concentrations are predicted to increase in the region due to the project. Ozone modelling done for the region predicted that the maximum hourly average ozone concentration would increase over baseline by approximately 10%. The baseline given in the report by BOVAR was 85 ppb, which did not include the new Aurora Mine. With the inclusion of the Aurora Mine emissions the baseline increases to about 94 ppb. The report also predicts that, with the addition of the Shell and Mobil Oil projects, the peak ozone concentration could increase to 100 ppb.

Response 52.1 Under a joint Shell, Syncrude and Suncor initiative, the CALGRID model is being used to remodel ozone levels for the region. For results of the modeling, see Section 7.3 (Ozone Formation) in the Project Update.

Request 52.2 Ozone in the region regularly (i.e. >35% of the time) exceeds the daily maximum (24 hour average) of 25 ppb. This value is more biologically relevant to plants than is the one hour, although acute exposures to high hourly values can still cause damage.

Response 52.2 See the response to OSEC 52.1.

Request 52.3 Plants are most sensitive to ozone at the peak of their activity (i.e. when their stomata are fully open), and are therefore most sensitive to ozone-related injury in the late spring and early summer period (and during the daytime). The ambient monitoring data from the Fort McMurray station indicates that the peak ozone concentrations found in the region occur mainly during the late spring and at mid-day.

Response 52.3 No response necessary.

Request 52.4 Ozone is known to adversely affect vegetation at the concentrations frequently found in the region. Ozone impacts on vegetation are also cumulative over time, and are usually enhanced by the presence of other pollutants.

Response 52.4 No response necessary.

Request 52.5 The current ozone guidelines are under review federally and new more stringent ozone guidelines are expected soon.

Response 52.5 See the response to OSEC 35.4.

Question No. **2.3.2 (20)**

Shell No. **OSEC 53**

Issue **Terrestrial Ecosystems – Adverse Effects on Vegetation from Increased Acid Deposition**

Request The Oil Sands Environmental Coalition is concerned that the predicted increase in regional acid deposition will negatively affect vegetation and terrestrial ecosystems.

53.1 Modeled values for the total acid loading (PAI) are predicted to be in excess of the interim critical loading for sensitive ecosystems, as well as the suggested value for moderately sensitive ecosystems (pg. F9-11), over large portions of both the local and regional study areas.

Response 53.1 See the response to OSEC 51.1.

Request 53.2 Portions of the local and regional study areas have been assessed as having soils which are highly and moderately sensitive to acidification.

Response 53.2 See the response to OSEC 47.3.

Request 53.3 Vegetation impacts from acidification could be evident at the levels of acid deposition predicted and presented in the EIA.

Response 53.3 See the response to OSEC 51.1.

Question No. **2.3.3 (21)**

Shell No. **OSEC 54**

Issue **Biodiversity**

Request The Oil Sands Environmental Coalition is concerned that the Project will result in a potentially significant loss to genetic biodiversity in the area at a number of scales.

54.1 In the section of the EIA on biodiversity measurements (EIA Volume 3, Part 1, E7.2.2), the proponent states that the discussion of genetic scale biodiversity is beyond the scope of the EIA. Although specifically measuring genetic biodiversity may be beyond the scope of the EIA, a discussion of how to maintain it through the preservation of biodiversity at other scales is not. Many species are locally adapted, rare or uncommon (for example rare plants). Such species contribute to local genetic biodiversity. Locally adapted, rare or uncommon species, if present, should be identified and the potential for the loss of genetic biodiversity through loss of these species assessed.

Response 54.1 Reclamation using native species from a number of different seed sources (that meet with provincial seed guidelines for native species) and natural colonization over time will provide the basis for maintaining of genetic diversity within the Muskeg River Mine Project area.

Request 54.2 The EIA notes that community level biodiversity can be assessed by comparing the number of vegetation patches (or polygons) within the LSA before and after the project (E9-27). Table E9-12 shows that 16 out of 18 vegetation types will have some degree of loss of patches, with a 31% average loss across all vegetation types. This is a significant reduction in community level biodiversity.

Response 54.2 Although patch size is expected to be less diverse during the initial stages of reclamation, it is expected that variability in patch size will increase with vegetation succession in the reclaimed landscapes. Progressive reclamation over the life-span of the mine will also allow for multi-aged stands to re-establish on the reclaimed landscape. The creation of microterrain variations will also increase the patch size diversity.

Request 54.3 Throughout section E-11 repeated references are made to the importance of mature forest to wildlife, both in terms of age of stands but also the size of stands.

Please provide a map indicating the location of stands of mature and old-growth forest in the LSA, and discuss the plans that the forestry companies have to harvest these stands.

Response 54.3 A map of AVI polygons with detailed database of forestry attributes is provided in the *Forestry Baseline Report*. Shell will work with the forest companies being affected by the Muskeg River Mine Project to address timber harvest plans.

Request 54.4 There is expected to be a loss of biodiversity at a landscape level. Table E7-4 indicates that there will be an overall loss in macroterrain diversity from a Shannon diversity index value of 1.01 to 0.78. The application notes that this is reflected in the reduction in mean macroterrain size from 685 to 413 ha, a 60% reduction. The magnitude of losses to specific macroterrain units such as the Creeburn Organic Plain (a decrease of 1.03 to 0.86) is also of concern. Although the same number of macroterrain units will exist after development, the reduction in the Shannon diversity indices suggests that species occupying the remaining area will be more vulnerable to further disturbance.

Response 54.4 The Shannon Diversity Index is one method to quantify landscape, community or plant species diversity, or species richness. Specifically, it is a measure used to incorporate the sum of the proportional contributions of an individual to the total population. The individual can be either plant species within a plant community or a plant community within a fixed area of land.

Minimal values occur when one species or plant community has a disproportionate dominance. Maximum values occur when all species or plant communities share equally in the dominance of the community. As such, this reduced number suggested that there is shift in dominance within the macroterrain unit. The reduction in the value for the Shannon Index partly results from lumping all reclaimed landscapes into one unit in EIA Volume 3, Part 1, Table E7-2. In reality, there will be a number of reclaimed units that will each have unique characteristics and thus will add to the diversity of the landscape.

Also it is not suggested in the EIA that the Shannon Index provides the only basis for assessing biodiversity. It is one of three measurements in which biodiversity was assessed. The other methods of assessing biodiversity used in the EIA were the assessment of richness and the size of landscape units. Macroterrain richness does not change between pre-development and far future conditions, and the size of the landscape units are not altered beyond the range of natural variability within the RSA following reclamation. Thus, species occupying the far future landscape should not be more vulnerable to further disturbance.

Request 54.5 The reclaimed landscape will have less biodiversity than the pre-disturbance landscape. The section on Closure Goals and Policies (E16.3.1) states that one of the goals is that areas will develop as self-sustaining ecosystems with an acceptable degree of biodiversity.

How is "acceptable" defined within the context of this goal?

Response 54.5 Acceptability is defined in the context of current reclamation targets which are for "equivalent land capability", and to provide a self-sustaining ecosystem. Reclamation practices are designed to establish the potential to achieve pre-disturbance biodiversity levels for upland communities. However, where practical, efforts to improve topography, soils, vegetation and patch size diversity during the reclamation process will be undertaken. Shell will monitor changes in plant biodiversity. See also the response to AEP 35 on Shell's Monitoring Committee.

Request 54.6 The application states that Natural Conservation Areas are an integral part of reclamation planning and maintenance of biodiversity. The application notes that a portion of reclaimed lands should be set aside for the development of natural ecosystems, with no intention of land or vegetation re-disturbance.

Describe the total area of the reclamation landscape that may be set aside in such areas and provide a map indicating the location of these areas.

Response 54.6 No firm decisions have been made about the relative proportion of the reclamation landscapes that will be set aside for the development of natural ecosystems. These proportions will evolve from future negotiations with government and a variety of other key stakeholders. As a participant in the Oil Sands End Land Use Committee, Shell will follow the potential land use options identified in the final report and recommendations. One such option is the establishment of Natural and Conservation Areas.

Request 54.7 Disturbances of landscape units that have been identified as having significant impacts, for example Creeburn Organic Plain, Boucher Organic Plain, and the MacKay Upland are rated as moderate, low, and low respectively. The landscape units identified above have been previously identified as important habitats for several species. The application also notes that "impacts to diversity at the species scale are only discussed conceptually since it is difficult to determine how species composition and structure will change" (E7-3). Considering the uncertainty involved in these predictions, the degree of concern assigned is too low.

Response 54.7 The degree of concern for disturbance to landscapes should be moderate.

Request 54.8 The total area of macroterrain units predicted to be disturbed as a result of all of the regional development is approximately 51,471 ha (or 4.9% of the RSA). Of this total, 1.5% or 15,430 ha of the Steepbank Organo-Lacustrine Plain will be lost (F7-3). The EIA states that no macroterrain units will be completely removed and therefore the overall biodiversity will not be significantly altered. This is a significant loss.

Response 54.8 The EIA Volume 4, Table F7-2, indicates that the total area of the Steepbank Organo-Lacustrine Plain to be removed in the RDR scenario is 275,427 ha, of which 15,430 ha will be lost to development. However, only 3,459 ha or 1.3% of the RSA is the loss associated with, and the residual impact which may be attributed to, the project. Using the criteria defined for residual impact analysis is consistent with the low degree of concern assigned in Table F7-3.

Request 54.9 The Summary of Predicted Impacts, Table F8-12, describes reclamation of developed areas with a reclamation soil mixture as a positive impact because it will increase the diversity of terrain units. The value of converting productive wetlands to a upland terrain units such as sand capped CT, overburden capped CT, and end-pit lakes is questionable.

Response 54.9 The question is unclear because of the confusion of terrain and soil issues. The issue of soil capability for forest ecosystems versus wetland ecosystems is discussed in the response to OSEC 48.1 and OSEC 48.2.

Question No. **2.4.1 (22)**

Shell No. **OSEC 55**

Issue **Human Health – Increased Exposure to Air Pollutants**

Request The Oil Sands Environmental Coalition is concerned that increased regional air emissions and water emissions related to oil sands developments will have a negative impact on the health and quality of life of individuals living in the Fort McMurray region.

55.1 Elevated levels of metals and PAHs in surface waters during operational and post operational stages of the project will increase the exposure of residents of the vast areas of reclaimed landscape to water borne and food borne contaminants.

Response 55.1 The conservative human health risk assessment indicated that:

- the predicted waterborne exposures to metals and PAHs in the Muskeg or Athabasca rivers during recreational activities (operation and post-closure) were about 10 to 100,000-fold less than levels associated with adverse effects

- in some cases, marginal risks were identified for naturally elevated baseline concentrations (e.g., arsenic and beryllium)

- multi-media exposures (including drinking water and ingestion of plants and animals) for a hunter or trapper living for 50 years on the reclaimed landscape were about 10 to 1000-fold less than levels considered acceptable

In spite of the conservative assumptions used in the assessment for both the operation and closure periods, and the comprehensiveness of the multi-media exposure, predicted risks to human health remain low.

Request 55.2 The Muskeg River Mine land base currently has the potential to support human habitation. Shell states (pg. E12-3) that hunters and trappers live on the reclaimed landscape for extended periods of time, yet the human health impact analysis focused on exposure of people who use off-site water-bodies for recreational activities, such as swimming, boating, fishing and hiking, during the operation and following closure of the project. There is a potential that resident hunters and trappers will use river water as a primary source of drinking and cooking water in the future.

Please clarify how the assessment of human exposure to water intake was conducted. Was this assessment limited to only occasional uses?

Response 55.2 The wording of this question suggests that there might be some misunderstanding of the human health assessment. Therefore, the following text is meant to clarify the presentation of results in the human health impact assessment with respect to water quality issues.

Two separate assessments were conducted for waterborne exposures:

- Key Question HH-1 addressed recreational exposures to water from the Muskeg and Athabasca rivers (e.g., swimming and occasional consumption of untreated river water while fishing, boating and hiking) during the operational phase and following closure.

- Key Question HH-7 addressed residential use of the reclaimed landscape of the Muskeg River Mine Project by hunters and trappers following closure, including ingestion of all drinking water from the Muskeg River and consumption of plants and animals harvested from the reclaimed landscape.

Therefore, both types of uses were evaluated in the impact assessment and risk estimates were less than the critical value of 1 for HH-1 and HH-7, indicating that exposures are acceptable for these human activities near and within the development area.

Request 55.3 The EIA, Page E12-16, notes that there is insufficient information regarding chronic toxicity of naphthenic acids but that they remain a compounds of interest for evaluation of human health. It is also noted that Canadian researchers are undertaking preliminary work in this area through sponsorship, in part, by members of the oil sands industry.

Is Shell sponsoring this research?

Response 55.3 Shell is not currently funding this research on chronic mammalian toxicity of naphthenic acids and CT water. However, Shell will work with other oil sands operators in the future to address issues associated with CT waters and naphthenic acids.

Request 55.4 Please provide an update of this area of research.

Response 55.4 See the response to OSEC 55.3.

Request 55.5 Predicted particle emissions primarily associated with mine fleet exhaust, and other combustion sources exceed Health Canada proposed Air Quality Objective levels.

Please discuss how this will be addressed.

Response 55.5 Although Health Canada has presented a draft discussion paper outlining various air quality objectives for PM_{10} and $PM_{2.5}$, there remains significant controversy in the scientific community (e.g., annual meeting of the Society of Toxicologists, Seattle, Washington, March 1998) concerning the reference levels for health effects of PM_{10} and $PM_{2.5}$ and appropriate guidelines. Consequently, it is premature to discuss specific actions to address the proposed Health Canada air quality objective levels. Other established air quality objectives for particulate matter (e.g., US EPA and B.C. Environment) are much higher than the proposed Health Canada guidelines and the predicted PM_{10} levels for the Muskeg River Mine project comply with these guidelines.

Request 55.6 The levels of NO_x emission modeled in the RDR are of concern from a human health perspective. The discussion of potential human health impacts associated with increased ambient NO_x should not be limited because levels are not expected to rise above existing guideline levels.

Why did the RDR discussion of human health impacts not include a consideration for increased non-oil sands related NO_x emissions? Please explain the basis for discounting the potential of human health impacts associated with the sub-guideline increases predicted in the RDR.

Response 55.6 The decision not to evaluate subguideline levels of NO_x is consistent with the chemical screening approach used throughout the assessment for all chemicals. This screening process is designed to focus the risk assessment on those chemicals which are present at levels that might be associated with health risks. As predicted NO_x concentrations were less than regulatory guidelines for the protection of human health, NO_x was not evaluated further in the risk assessment.

In the air quality impact assessment for the RDR, the predicted level of NO_x (39 ug/m^3) was conservatively compared to the Alberta guideline for NO_2 (60 ug/m^3), assuming that all NO_x consisted of NO_2. In spite of this conservative assumption, the predicted level of NO_x for the RDR was still in compliance with the regulatory guideline. Therefore, predicted levels of NO_x /NO_2 for the RDR are considered to be acceptable.

Request 55.7 Ground-level ozone concentrations are also a concern for human health impacts. In explaining the need for further ground level ozone modelling the RDR notes that the level of confidence of the VOC estimates is lower than the estimate of NO_x emissions. The EIA is also vague about timelines for additional ozone modelling and about Shell's response to potential model outcomes.

Why is the RDR silent on the impact of ground level ozone on human health when the EIA states that existing guidelines have been exceeded in the past and will likely be exceeded in the future?

Response 55.7 Emission estimates have been updated by Suncor and Syncrude since the Muskeg River Mine EIA was prepared. The NO_x emissions in the EIA are similar to the updated emissions. As discussed in OSEC 20 and OSEC 38.2, there are considerable differences with respect to VOC emissions.

Shell is working with Syncrude and Suncor in supporting the application of the CALGRID model to the region. Plans are to apply the model on an event basis to predict ozone concentrations during the period when high ozone concentrations have historically been observed (end of April and beginning of May) and to a period when temperatures are the warmest (end of July and beginning of August). The application of the model will be based on the most recent estimates of NO_x and VOC emissions. The results are predicted in Section 7.3 (Ozone Formation) in the Project Update.

Request 55.8 What is the expected timeline for the completion of the modelling of ground-level ozone?

Response 55.8 See Section 7.3 (Ozone Formation) in the Project Update.

Request 55.9 Changes in the quality of the water, air, vegetation and wildlife, even if below regulatory guidelines, do affect the quality of life of residents of the region. The EIA does not discuss the potential of impacts on quality of life associated with these changes to the environment in the region.

Please discuss how this issue will be addressed.

Response 55.9 Quality of life issues are addressed in EIA Volume 5, Socio-Economic Impact Assessment. These issues are also being addressed directly with regional stakeholders who are affected by the Muskeg River Mine Project through such organizations as the Industry Relations Corporation.

Question No. 2.4.2 (23)

Shell No. OSEC 56

Issue **Animal Health - Adverse Effects by Project Emissions**

Request 56.1 The linkage diagram for wildlife, Fig. E11-1, does not address the potential effects of air emissions on animal health. The application notes that toxicity assessments for wildlife health focus on the protection of populations rather than individuals, as is the case with human health. The assumption is made that the effects of air emissions on wildlife would only be expressed through effects on vegetation. The application states that air emissions would not impact vegetation and therefore impacts on wildlife were also assumed to be negligible (E11-30). However, air emissions have the potential to significantly affect the health of individuals which could lead to changes in population parameters.

Please clarify how this issue will be addressed for air emissions of concern such as HAPs, ozone, and particulates.

Response 56.1 The statement in EIA Volume 3, Part 1, Page E11-30 focuses on impacts to wildlife *habitat*, not wildlife *health*.

With respect to the effects of air emissions on wildlife health, the wildlife health assessment for key question W-3 (Page E11-69) focused on the indirect exposure to airborne chemicals following deposition onto plants and subsequent ingestion. This pathway was classified as having a negligible impact.

Although wildlife might be exposed to chemicals in the air by direct inhalation, this route of exposure is typically considered to be minor for wildlife. However, airborne chemicals deposited directly onto plant surfaces or taken up from soils can be ingested by animals. The results of an animal tissue sampling program conducted in 1994 near operating oil sands facilities suggest that ingestion is the primary exposure pathway for animals in the oil sands area.

There is also considerable uncertainty associated with risk predictions for wildlife based on inhalation exposure due to:

- the limited amount of inhalation toxicity studies conducted with wildlife
- the difficulty in extrapolating from laboratory animals to wildlife to determine the dose deposited and retained via the respiratory tract of various wildlife species (i.e., requires detailed knowledge of the respiratory anatomy and physiology of each species).

Request 56.2 The Oil Sands Environmental Coalition is concerned that the increased releases of pollutants into the environment will result in negative impacts on animals. This concern mostly focuses on the effects of chronic low level exposure to toxic substances on animal health from a number of pathways.

Response 56.2 The wildlife health impact assessment considered multi-pathway exposures to wildlife in key question W-4 for the operation phase (EIA Volume 3, Part 1, Page E11-76) and in key question W-7 for exposures on the reclaimed landscape (Page E11-98). The effect endpoints chosen for evaluating wildlife health risks are primarily based on reproduction, although growth was considered if it was more sensitive. These studies were based on chronic low level exposure. By using these endpoints as a basis for evaluating chemical emissions from the project, the effects of chronic low level exposure and the potential for adverse effects to the reproductive capability of future generations of animals were evaluated.

Chemical releases to the aquatic environment were examined in the water quality and aquatic resources impact assessments. Predicted levels of chemicals and toxicity were compared against guidelines for the protection of aquatic life. In this way, the effects of low levels of exposure to chemicals in the aquatic environment were examined. Predictions made in the impact assessment will be verified by a laboratory fish health study (which is being supported by Shell) of the effects of exposure to CT water on fish.

Request 56.3 A number of potentially toxic substances have been identified in fish and invertebrate tissues such as PAHs, some metals, and naphthenic acids. The application notes that monitoring will be carried out as part of the regional Aquatics Monitoring Program (RAMP) to monitor for potential effects from these substances and that research should be done to assess the toxicity of naphthenic acids (E11-69). Monitoring of parasites is a technique that should be considered for use; as it can be very useful when concentrations of substances of concern are low or below detection limits. Parasites can accumulate toxins, and could be useful for monitoring for the accumulation and effects of chronic exposure in invertebrates, fish, and mammals.

Response 56.3 A detailed fish health study is currently being designed to assess the effects of CT on several fish stages (see the response to OSEC 40.3) and naphthenic acid studies on chronic effect on mammals are being funded. In addition, fish health monitoring is included in RAMP. If additional monitoring for toxic substances is deemed important after these studies have been completed, the monitoring of parasites could be considered as part of RAMP.

Request 56.4 The application states that the plant species used to address wildlife health issues were the same as those used to address human health issues, i.e. blueberries, Labrador tea, and cattail roots. The inherent assumption is that these species adequately reflect wildlife consumption for the purposes of assessment.

Please discuss if there are any plant species which may be important food sources for wildlife (e.g. lichens, plant roots, tubers) that are not used by humans and therefore were not assessed.

Response 56.4 These plant species are not necessarily the best to use for evaluating effects to wildlife. However, as stated in EIA Volume 3, Part 1, Page E11-69, the vegetation-sampling program was originally designed to examine the potential for uptake of contaminants into foods consumed by humans. These data (berries, leaves and roots) were used as surrogates for chemical concentrations in other plant species used by wildlife, since this was the best data available at the time of writing. Regardless, some wildlife species do consume these plants (i.e., bears eat blueberries, moose and mallards eat aquatic plants like cattails, herbivores eat low bush leaves like Labrador tea). In addition, berries, leaves and roots were sampled to give an indication of chemical concentrations in different parts of plants that humans and wildlife might consume. The field is not a controlled environment which would provide a definite cause and effect analysis.

Request 56.5 The application states that no acute or chronic effects on fish are predicted (pg. F6-18). However, this conclusion is based on a number of assumptions. For example, lab toxicity tests are not always applicable to field conditions. There is a lack of knowledge of the effects of CT water on fish health. CT releases from all developments have the potential to adversely affect fish health.

Please discuss what plans Shell has to conduct field research on the effects of CT on fish health.

Response 56.5 Although laboratory studies are not always directly applicable to field conditions, the fish health study that Shell plans to participate in will represent a worse-case exposure scenario. The concentrations that the fish will be exposed to in the lab will be much higher than those that are predicted to occur in the local study area.

See the response to OSEC 40.3 for more details on the fish health study. If any fish health parameters respond to CT water, these will be monitored in fish in the field. Fish health monitoring will be included in the RAMP. However, releases of CT to the environment will not occur for a few decades. Therefore, the laboratory studies will provide an initial indication of potential issues that can then be resolved before the release of CT waters.

Request 56.6 The application states that no wildlife health impacts are predicted from the combined exposure to water, aquatic invertebrates, and plants.

Will this assessment still be valid if effects from air emissions on wildlife health are added?

Response 56.6 This statement would still be valid, since the inhalation exposure pathway is negligible in comparison to exposures obtained through the food chain. See the response to OSEC 56.1 for a detailed explanation of why direct inhalation of airborne chemicals by wildlife was not evaluated.

Request 56.7 Atmospheric releases of toxic substances may be deposited and accumulate in the snowpack over the winter, and then be released in a pulse in the spring. This may affect both aquatic vertebrate and invertebrates in critical periods of their life-cycles.

Could there be additive or synergistic effects of substances deposited on snow and released into aquatic ecosystems in a pulse due to snowmelt? If this is the case, substances identified as being present in low concentrations e.g. metals could be present in much higher concentrations for short periods of time.

Response 56.7 No known information exists with which an assessment could be made. See also the response to AEP 33 on acid spring pulse monitoring.

Request 56.8 Amphibians use both terrestrial and aquatic habitats and are considered sensitive receptors. Monitoring for additive or synergistic effects could be made more effective by the addition of an amphibian receptor. Possible species for consideration are the wood frog (*Rana silvatica*) or the boreal chorus frog (*Pseudoacris maculata*) which are abundant. Another species, the Canadian toad (*Bufo hemisphrys*), is reported as being in decline and may be worth monitoring as a sensitive species.

What plans does Shell have to monitor amphibians populations or to include an amphibian as a KIR in the EIA impact assessment?

Response 56.8 Waterbodies within the plume dispersion of the Muskeg River Mine Project are considered well buffered (see the response to OSEC 45.1). Therefore, amphibians were not selected as KIRs. The KIRs were selected in consultation with regulatory and public stakeholders.

Currently, a graduate student at Simon Fraser University is conducting research on tadpole development within wetlands receiving dyke drainage and CT water.

Monitoring of amphibians could be considered for inclusion in the RAMP program if the regulators and other key stakeholders consider its inclusion important.

Request 56.9 The effects of air emissions from the combined projects are addressed only through potential increases in chemical concentrations in plant tissues. There is also concern about the direct effect of air emissions such as HAPs, ozone, and particulates on individual animals which could lead to negative impacts on populations.

Response 56.9 See the response to OSEC 56.1.

Request 56.10 The application notes that naphthenic acids were identified as potential chemicals of concern for animal health, but that due to the lack of chronic toxicity data they were not assessed in the CEA (F11-4). The degree of uncertainty associated with these chemicals would suggest that their assessment for the RSA is important.

Please discuss how this data deficiency will be addressed on a regional basis.

Response 56.10 See the response to OSEC 55.3.

Question No. **2.4.3 (24)**

Shell No. **OSEC 57**

Issue **Wildlife Populations - Adverse Effects from Habitat Removal**

Request The Oil Sands Environmental Coalition is concerned with the effects of habitat removal on wildlife.

57.1 The application notes that the loss of winter range can significantly impact moose because they tend to be traditional in their use of seasonal ranges (E11-31).

Please provide information on the areas of the project used by moose for winter range, including mapped, and discuss the implications of loss of these areas on moose populations.

Response 57.1 Habitat suitability maps for moose are presented in the *Wildlife Habitat Suitability Indices Modeling Baseline Report.* Habitat variables that are correlated to winter habitat use (e.g., browse abundance, cover) were incorporated into the moose model. Although the loss of moose habitat capability is predicted to be 54% of the LSA as a result of construction of the mine, following reclamation, moose habitat is expected to increase in availability by 10% over baseline conditions.

Some recent EIAs (e.g., the Aurora EIA) considered that the local moose population was below the carrying capacity of the habitat. This conclusion was based on the abundance of unbrowsed deciduous shrubs in the Aurora LSA, and the work of others (Hauge and Keith 1981; Delta Management Group 1990) that suggested that moose numbers were below the carrying capacity because of wolf predation and hunting. The Aurora EIA thus concluded that a portion of the moose displaced by the Aurora Mine would survive in this "unoccupied" habitat.

Data collected during the Shell EIA was too limited to make any definitive statements about whether or not the local moose population was at or below its carrying capacity. However, it is likely that the population is in an equilibrium that is balanced by habitat availability, predation, hunting and poaching, parasites, weather and other factors. Therefore, while moose that will be displaced from the Muskeg River Mine are likely to survive over the short-term, it is expected that the population of moose surrounding the development will revert to this same equilibrium level over the mid- to long-term. Therefore, the EIA took the conservative approach in assuming that all displaced moose, or an equivalent number, will not survive.

Definition of the local moose population is not possible with existing information. Therefore, the implications of the loss of 54% of moose habitat capability in the LSA on the moose population is difficult to ascertain. However, it is conjectured that the local moose population (extending beyond the LSA) is sufficiently large and dispersed that the loss of some 2,540 Hus within the LSA (54% of habitat available) will not jeopardize the long-term survival of this population. Based on moose population estimates from regional studies, it is likely that between 8 and 25 moose reside within the area that will be impacted (including effects for site clearing, drawdown and disturbance). Therefore, the population will likely decrease by that amount until the land is reclaimed.

Request 57.2 The application notes that in order to provide adequate corridors for wildlife movement an additional east-west corridor should be provided south of the tailings pond. The application also notes that such a corridor would extend south of Lease 13 (E11-53). The development of such a corridor would have to be integrated into the planning of any development south of Lease 13. Unless planning for this corridor can be assured, the proponent should allow for the corridor on the present lease.

Please discuss what plans Shell has to work with other industry players in the region to ensure that this does happen.

Response 57.2 Shell will consult with government agencies, other oil sands operators and other key stakeholders to determine the need for maintaining or creating wildlife corridors within the LSA. This effort could involve the formation of a corridor committee.

Request 57.3 Several areas of uncertainty exist with predictions of how habitat loss with affect wildlife. The application notes, for example, that most displacement models rely on professional judgment using empirical data as a guide only (E11-9), and that the impacts of barriers are difficult to predict due to the lack of information on wildlife movements in the LSA (E11-60). This uncertainty seems to be reflected in the assessments for habitat loss which are rated as with moderate or moderate-high (Table E11-19). The proponent has committed to monitoring to assess the effects of habitat loss on wildlife.

What contingency plans does Shell have to deal with this if impacts on wildlife are greater than anticipated?

Response 57.3 The conservative nature of the assessment (i.e., impacts were determined as if all site clearing were to occur at one time, without any phasing to clearing or reclamation) should compensate for the uncertainties outlined.

If the local wildlife corridor network is shown to be ineffective through monitoring, Shell will work with the local AEP wildlife personnel to develop suitable mitigation plans.

Request 57.4 Mitigation of habitat loss will depend on effective cooperation between government, industry, and residents, as stated in the application (F11-3).

Please discuss plans for the development of a regional wildlife management strategy.

Response 57.4 Shell would willingly participate in a regional wildlife management strategy initiative.

Request 57.5 Mining operations may have unassessed, indirect impacts on wildlife populations in the region. The EIA mentions that blasting will occur when the ore body is frozen. Blasting is an intermittent activity which produces high levels of stress disturbance.

Please provide a discussion of the effect of blasting on wildlife populations.

Response 57.5 Areas of blasting are within the mining area. Therefore, animal use of the area is minimal and the effects of blasting will be low.

Request 57.6 Low-density wildlife (such as fishers) with slow reproductive rates are threatened by the development within the region. The EIA notes that Fishers are susceptible to extirpation and have been reduced to near extinction in many areas while winter track counts indicate that they are relatively abundant in the Project Region.

Please discuss how population viability of low-density wildlife will be affected by the cumulative regional developments.

Response 57.6 The population viability of low density species within the region will be maintained if an adequate supply of habitat is maintained in the region at any point in time and if a network of local and regional wildlife corridors is maintained within and between developments. However, regional planning might be required. Such planning would require interagency cooperation (e.g., Fish and Wildlife and Forestry) and other principles of ecosystem management. Shell is willing to consult with government agencies on this issue.

For example, extirpation of fishers from areas has mostly been due to overtrapping. Fishers are easily trapped and are highly sought after by trappers when the price of fisher pelts is high. Therefore, post-closure trapping in the LSA might encourage the recovery of fishers in this area.

Question No. **2.4.3 (24)**

Shell No. **OSEC 58**

Issue **Fish and Wildlife Populations – Effects of Increased Access**

Request The Oil Sands Environmental Coalition is concerned with the effects of increased access on fish and wildlife populations.

58.1 The EIA notes that increased access to the area would impact on wildlife populations from increased hunting. The EIA states that controlling hunting in the reclaimed area, and setting harvest and trapping limits, are responsibilities of the provincial government (pg. E11-110).

What plans does Shell have to limit access to the area as part of the closure planning?

Response 58.1 Because of safety concerns, Shell will not allow the public to access the development areas during project construction and operation.

Shell expects to reclaim all roads. However, AEP might direct Shell to leave some roads for future oil sands, recreational or other uses. Decisions on future access will not be made for many years.

Request 58.2 The EIA notes that an increase in fishing pressure after closure could cause a decrease in fish abundance. The EIA notes that regulation of angling is the responsibility of AEP and assumes that they will enforce the appropriate legislation.

What plans does Shell have to control access in their closure plan?

Response 58.2 See the response to OSEC 58.1.

Question No. 3.1 (25)

Shell No. OSEC 59

Issue **Land and Resource Use – Conflicts**

Request

The Oil Sands Environmental Coalition is concerned that the proposed Muskeg River Mine, along with the various other existing and approved mines in the region, will result in conflicts with other resource uses of the area.

59.1 Previously allocated timber harvest rights may conflict with the long-term reclamation and land use objectives of the Project. An example of this is the desire to preserve mature stands of forests as important ecological units.

Please provide information on the timber harvesting schedule for the Local Study Area.

Response

59.1 Timber harvesting agreements, patterns and schedules will be established later based on discussions between Shell, BHP and the forestry companies.

Request

59.2 Increased development and access to the area will likely result in negative impacts on traditional resource use, including trapping, hunting, and fishing. Other commercial activities such as commercial hunting may also be adversely affected by the Project.

Please comment on this.

Response

59.2 Shell has been meeting with the community of Fort McKay since the spring of 1997 to better understand the concerns of the community related to the proposed Muskeg River Mine development. Shell and Fort McKay representatives are currently meeting weekly and have established a process to identify and prioritize Fort McKay's socio-economic and environmental concerns or issues, propose mitigation plans, and agree on actions required for mitigation. This process has included discussions on the impacts on traditional land use, including trapping, hunting, fishing and gathering.

In addition, Shell has plans in place to adequately compensate the two registered trapline owners affected.

Request

59.3 Non-consumptive commercial use of the area, such as dog-sledding and guided tours, depend on the quality of the environment in a number of senses. Part of what they sell and provide to clients is a "wilderness" experience.

How will this project impact on this commercial activity?

Response

59.3 Depending on the final preferred end-land uses recommended by key stakeholders for the Muskeg River Mine Project area, part of the reclaimed landscape might be left as natural areas. These areas, and those identified for forestry (for the medium term), would provide wilderness experiences. During construction and operation, the Muskeg River Mine Project area would attract visitors who wish to view a large-scale mining operation.

Question No. 4.1 (26)

Shell No. OSEC 60

Issue Mine Planning

Request

The Oil Sands Environmental Coalition is concerned that the proposed Muskeg River Mine, in combination with the various other existing and approved mines in the region, could result in negative environmental impacts that could be partially avoided or minimized through enhanced mine planning.

OSEC is of the view that oil sands operators should coordinate mining activities in order to minimize the proliferation of unnatural end-pit lakes in the region. Shell discusses a common end-pit lake on Page 4-45. This situation will change if Syncrude gets approval for the proposed Syncrude 21 project.

60.1 What plans does Shell have to re-evaluate this plan with Syncrude?

Response

60.1 Shell and Syncrude have discussed, and will continue to discuss, mine planning issues in accordance with the Oil Sands Development Principles of Cooperation (see Volume 1, page 1-32). For details of recent cooperative initiatives, see Section 1.2 (Regional Cooperation) and Section 3.4 (Lease Boundary Management) in the Project Update.

Request

60.2 There could be a number of opportunities to minimize impacts and the area disturbed by working cooperatively with neighbouring projects.

Has Shell explored other possibilities to work in cooperation with Syncrude to reduce the degree and duration of impacts associated with oil sands mining in the region including sharing of overburden storage, earlier movement of overburden to mined out areas, earlier placement of tailings in-pit?

Response

60.2 Shell and Syncrude have investigated several areas of coordinated mine planning, as outlined in Volume 1, Section 4-6.

Overburden storage areas are of particular concern in mine planning. Resource sterilization, haulage costs, environmental impacts and reclamation all play a significant role. Specific studies into initiatives involving sharing overburden storage between Shell and Syncrude have not yet been investigated in detail.

Shell, Syncrude and Mobil will continue to explore opportunities for sharing mine plans and for joint mine planning where mining and reclamation should be harmonized to ensure efficient resource recovery and reclamation.

Request

60.3 The application notes (pg. 4-30) that Shell intends to use 218-tonne trucks and existing-sized shovels for the Muskeg River Mine, with the intention of evaluating the larger 300-tonne trucks in the future. Section 4.1 of the application does not discuss mine planning from an air emission point of view. It may be possible to reduce VOC emissions by reducing the size of the active mine face.

How has Shell incorporated the consideration of emission minimization into mine pit planning?

Response 60.3 The principal objectives of the mine plan are discussed in Volume 1, Section 4.2, Page 4-5.

The size of the mining face is designed to allow sufficient blending of oil sand to provide the extraction plant with a consistent feed grade. This provides the opportunity for efficient operation of the extraction plant.

Whenever possible, Shell will minimize the amount of exposed mining face as detailed mine planning progresses.

Request 60.4 Please provide an update on Shell's consideration of appropriate truck size including a discussion about how this affects mobile air emissions.

Response 60.4 The introduction of 300-tonne trucks into the mining industry will develop over many years. New technologies for engines, tires, wheels and motors will require significant evaluation before 300-tonne trucks become a 'standard' sized truck. The impact on mobile air emissions will not be fully understood until a suitably sized engine is developed and field tested, and the operating efficiencies can be fully assessed.

Request 60.5 Section 4.2 refers to a need to construct a culvert type crossing of Muskeg River for transfer and overburden. The application states that detailed engineering, environmental assessment and mitigation planning will be completed in late 1999 before installation early in 2000.

Please discuss why the EIA for this river crossing is not part of this EIA? And why is a culvert type crossing preferable?

Response 60.5 The crossing of the Muskeg River by bridge and potential effects are discussed in Section 3.5 (Muskeg River Crossing) in the Project Update.

Request 60.6 The size of the tailings impoundment appears to be very large relative to the mine area.

How does the proposed tailings impoundment area compare to other oil sands operations on a production basis?

What possibilities exist to reduce the size of the impoundment area?

Response 60.6 As Shell's tailings settling pond will be used to store tailings at full production for only the first five years of operation, then at reduced production thereafter as a result of placement of CT in-pit, as described in the application, the pond is smaller than ponds in existing oil sands operations on a production basis. The tailings settling pond is minimum size, as it is not possible to place the material in the mine any sooner.

Request 60.7 The Muskeg River Mine proposed mine plan calls for clearing and draining of the mine site (2-5 years) prior to actual mining (Volume 2, pg. B-6). This practice does not appear to take into account the benefits of leaving natural cover in place as long as possible.

What is the key factor that determines when the surface must be cleared of vegetation?

Response 60.7 The orderly development of the mining operation requires sufficient time for preparatory activities ahead of mining the oil sand. These activities include:

- access development
- clearing
- surface drainage
- muskeg and overburden removal
- aquifer depressurization

The length of time for each activity will vary depending on the specific characteristics, such as the direction of mining, density of natural cover, muskeg and aquifer properties, seasonal influences and environmental implications.

Wherever possible, Shell will minimize the amount of vegetation clearing ahead of the mining operation, recognizing environmental implications as an integral part of the mine planning process.

Question No. **4.2 (27)**

Shell No. **OSEC 61**

Issue **Closure and Reclamation Planning – End-Pit Lakes**

Request The Oil Sands Environmental Coalition is concerned that the end-pit lakes proposed in this Project and other in the region has not been thoroughly assessed and could result in negative environmental impacts.

61.1 The proliferation of end-pit lakes in the region could permanently alter the microclimatic regime of the area.

Response 61.1 End-pit lakes are not expected to change the microclimate of the region. End-pit lakes are expected to slightly change the heat storage capacities at the locations of the lakes in relation to natural conditions. For example, the air temperature over the lakes will be slightly warmer during the freezeup period and cooler during the breakup period in relation to natural conditions. The relative humidity over the lakes will be slightly higher during the freezeup period and slightly lower during the breakup period. However, the magnitude of these changes is expected to be minor. In addition, the percentage of total end-pit lake area over the total regional area is relatively small. Therefore, these changes are expected to have negligible effects on the regional microclimate.

Request 61.2 Shell proposes a 24x increase in post reclamation surface water (pg. E4-73). This change could affect the quality and type of plant and animal life that can be sustained in the region.

Response 61.2 See the response to OSEC 42.2.

Request 61.3 How was the 20% littoral zone determined?

Response 61.3 The 20% littoral zone was based on AEP regulatory recommendations. A 10% littoral zone would be typical for a lake of this nature (Golder 1995).

Request 61.4 What type and level of biological activity is expected in the proposed littoral zone?

Response 61.4 Similar levels of biological activity in the littoral zone are expected to those existing in the littoral zones of larger lakes in the region.

Request 61.5 The end-pit lake, as conceptually described, is very deep (i.e. average depth of 62 m.) and extensive (442 ha) (pg. E6-40). This is likely too deep to support much biological activity. This lake may be oligotrophic and, even if approximately 88 ha of littoral zone is created, the ecological viability of the lake is questionable. The proposed littoral zone (20% of the lake volume) would help but the overall productivity of the lake is questionable.

What plans does Shell have to demonstrate the ecological viability of the end-pit lakes?

Response 61.5 There are other deep lakes in Alberta with similar characteristics, but with a generally smaller littoral zone area. The end-pit lake will be filled with mature fine tailings to a level that provides about 20 m of water cover, thereby substantially reducing the lake depth and volume to littoral zone area ratio.

A biologically productive end-pit lake is an objective of the regulatory agencies. Therefore, it is Shell's goal to work towards this objective.

Shell understands that there are many uncertainties associated with the end-pit lake, but believes that it can be designed and operated to achieve the desired result of a viable, productive, self-sustaining lake with a non-toxic outflow at all times. The key to achieving this goal is planning, researching and monitoring. Shell is committed to participating with other regional operators and regulators to achieve this goal. This regional approach will be used not only to continually fine-tune design and operational parameters, but to assess the overall feasibility of the end-pit lake concept, so that a viable alternative is available for reclamation.

Shell believes it will be necessary to form a dedicated, multi-stakeholder committee to ensure that the knowledge gained on end-pit lakes over the next decades is consistent with that required to ensure that the end-pit lakes are viable reclamation features at closure.

Request	61.6	Ultraviolet light (UV-B) is known to penetrate clear waterbodies and adversely affect organisms. Increases in UV-B radiation could have a harmful impact on the biological activity and organisms in the end-pit lakes. Please discuss the potential for impacts on aquatic organisms from increased UV-B radiation.
Response	61.6	Although it is expected that the end-pit lakes will be oligotrophic to mesotrophic, it is not practical to speculate how end-pit lake water clarity will affect UV-B levels at this time. The current understanding of the effect of changing UV-B levels on organisms is limited.
Request	61.7	Biological activity in the end-pit lakes is expected to mainly occur in the littoral zone. The remainder of the end-pit lake would have a significantly reduced capability for biological activity.
Response	61.7	Most productivity in any deep lake is limited to the littoral zone and upper few metres of water where light levels are sufficient to support photosynthesis. There is no reason why the photic zone in the end-pit lake would be unproductive, given adequate nutrient levels and light.
Request	61.8	The EIA suggests that the chemical additive for CT (gypsum OR acid) has not yet been decided. Will release water chemistry be affected by this decision?
Response	61.8	Suncor and Syncrude now use gypsum as the preferred additive in the production of CT. The change in chemistry is slight and related to the type of acid that would otherwise be used.
Request	61.9	The proponent intends to discard soil removed during construction and operation of the project. The application notes that salvaged soil/organic material not used for reclamation will be discarded (E8-7). Please provide detailed information on how much soil will be discarded and discuss ways to minimize the amount discarded.
Response	61.9	In the active mining area, soils and organic material will be removed as part of the preparatory and prestripping activities. Wherever possible and practical, this material will be directly placed as part of reclamation activities or stockpiled for future reclamation. Excess soils and organic material will be discarded because of the additional cost, clearing and management of unnecessary stockpiles, and to minimize the degradation of stockpiled soils and organic material. Stripping activities from the active mine area will support sufficient soils and organic material for reclamation. The amount to be discarded from these activities is expected to be minor.

Request 61.10 Stockpiled soils are proposed to be left to revegetate naturally (pg. E8-11). Soil stockpiles left to revegetate naturally may be subject to wind and water erosion before vegetation cover is established. In addition they may be colonized by non-native invasive species. Stockpiles should be seeded with a locally appropriate native seed mixture.

Response 61.10 As per current Syncrude and Suncor practices, overburden dumps will be seeded with barley or another nurse crop. Peat storage sites will be left to vegetate naturally. Natural revegetation of stockpiles should be rapid enough to minimize erosion potential, based on observations at the Suncor and Syncrude sites. Allowing natural regeneration from stolons, for example, is believed to be as viable as seeding.

Request 61.11 The surface area which is disturbed by mining activities should be minimized, and the land should be reclaimed to a productive and self-sustaining state as soon as possible.

What is the maximum extent of the total land area disturbed associated with the proposed Muskeg River Mine?

Response 61.11 The total area disturbed is estimated at 4,343 ha (see Volume 1, page 16-40). The reclamation schedule (see Volume 1, Page 16-42) details the progression of clearing and reclamation. The maximum total land area disturbed is about 2,200 ha at the end of 2007.

Request 61.12 Does Shell have any objectives for minimizing the disturbed area and the length of time that it is disturbed (i.e. from the point in time when trees are removed to the point that trees are restored)?

Response 61.12 Shell's decision to adopt truck-and-shovel mining for the Muskeg River Mine recognizes the significant benefits (over dragline and bucketwheel operations) of enabling the mining, extraction and tailings operations to be better coordinated and integrated with progressive reclamation.

As noted in the response to OSEC 60.7, Shell will minimize the vegetation cleared for development and will reclaim areas as soon as possible.

Request 61.13 The application notes that centre reject materials are likely to have chemical properties that may not be conducive to revegetation (E16-14).

Please discuss how centre reject materials will be disposed of and if there is any potential for contamination of surface waters or effects to vegetation.

Response 61.13 Centre reject material will be disposed of with overburden in one of the three major storage areas or within the mined-out pit. This material will be deposited in a manner that will ensure that there are no additional adverse effects to surface waters or vegetation.

Question No. 4.3 (28)

Shell No. OSEC 62

Issue **End Land Use - Objectives Definition**

Request 62.1 The Oil Sands Environmental Coalition is concerned with how a number of primary end land use objectives have been identified. The two primary land use objectives identified for the reclaimed landscape are commercial forest revegetation to a mixed wood boreal forest and the creation of moose habitat (pg. E9-36).

Please describe the consultation process used to develop these objectives. In particular, why is revegetation to mixed wood boreal forest a primary land use goal, since the reclaimed soils are rated as class 3 - low productivity for forestry?

Response 62.1 The final land use objectives and design for the reclaimed landscape will be completed based on consultation. Final decisions on the blend of land forms and vegetation communities will result from consultation with government and a variety of stakeholders and be influenced by reclamation research which will occur over the next 10 to 20 years. Forests capable of producing commercial timber will be a significant portion of the reclaimed landscape because of an obligation to replace the commercial forest productive landbase. The Oil Sands Mining End Land Use Committee report and recommendations will be considered in Shell's reclamation objectives.

Request 62.2 The application states that other end land use goals include the "development of self-sustaining ecosystems with an *acceptable level of biodiversity*; and drainage systems that have an *acceptable level of impact in terms of issues such as erosion and contaminant loadings* (pg. E9-36).

Please describe how acceptable levels have been determined within this context.

Response 62.2 Acceptable levels will be judged by the reclamation standards of the day. It is not productive to speculate on what those standards might be 20 to 30 years from now.

Question No. 5.1 (29)

Shell No. OSEC 63

Issue **Process Technology- Bitumen Extraction**

Request The Oil Sands Environmental Coalition is concerned that emissions to air and water associated with the proposed Muskeg River Mine, in conjunction with the development of other oil sands resources in the region, will result in significant impacts to the environment and to human health unless mitigated by lower emitting processes. Technology substitution could be used to reduce air and water emissions associated with bitumen extraction.

63.1 Shell is proposing an extraction temperature of 45 to 50 degrees C. It is unclear from the application and the EIA how these temperatures were chosen and whether lower temperature processes were considered. Lowering the extraction temperature would decrease the amount of fuel used and the related combustion emissions.

Please discuss options or opportunities that Shell has explored to lower the extraction temperature below the application case.

Response 63.1 The screening process Shell used to select the extraction process is covered in Volume 1, Section 5.4. A list of processes and process components considered are provided on Page 5-20. Included in this list is cold water extraction with coal flotation chemicals.

One of the screening criteria used was technical risk. Shell believes that, for a grassroots operation, there is additional technical risk in using technologies that have not previously been applied or demonstrated in a commercial setting.

Currently, there are no commercial oil sand operations applying low extraction temperatures (i.e., 25°C to 45°C). However, commercial operations have operated at process temperatures of 50°C for periods of time.

The selected process configuration does not preclude the use of lower process temperatures in the future. Shell will move to lower process temperatures once commercial and technical risk is acceptable.

Request 63.2 A 20 t/h pilot facility located on Lease 13 is planned for 1998. The pilot plant project provides Shell with the opportunity to measure VOC, TRS and PAH emission and to speciate samples.

Please provide details of the pilot plant environmental monitoring program.

Response 63.2 The pilot plant is still being constructed. An air quality monitoring program is being developed. Measurements to characterize and quantify point and fugitive sources of VOCs and TRS emissions will be conducted during the pilot testing program (see the response to AEP 16).

Request 63.3 A central crushing facility will require bitumen ore to be transported to it.

Has Shell evaluated a movable crusher or a system of conveyors that would keep pace with the progression of the active face and limit mobile fleet emissions?

Response 63.3 The concept of a movable crusher or a system of conveyors was investigated and rejected for the Muskeg River Mine Project.

A key feature of truck-and-shovel mining is the flexibility to blend different ore grades, ore types and interchange between overburden and ore mining. This allows for a dynamic operation which can quickly adapt to changing circumstances and allow the mobile fleet to be optimized. A system of in-pit conveyors would provide a transportation medium for the ore, but would significantly reduce the efficient operation of the mine, because of its inflexibility and the large quantity of ore required to be transported (12,100 t/h on a stream day basis).

The truck dump and crushing station are large installations, requiring the largest crushers available for the required tonnage throughput. They are not easily moved, and would require significant savings in truck haulage to offset the capital investment. Ongoing mine planning will include ore delivery option evaluations, including areas of environmental impact and benefits.

Request 63.4 Volume 1, Section 1.3 - The conventional froth treatment process presents problems for Shell in terms of meeting the water and solids specifications for commercial pipelines. The product clean-up step involves paraffinic solvent demulsification (PSD) process. PSD uses a small amount of heavy coke-like hydrocarbon material which can be preferentially removed with the tailings.

What impact will additional hydrocarbon in tailings have on CT formation and on air and water emissions?

Response 63.4 The additional coke-like hydrocarbons (asphaltenes) are solid materials and produce no vapours. When incorporated in CT mix, it is expected they will behave similarly to the mineral solids.

It is also expected they will not produce any incremental effects on water quality as they are inert. Further evaluation of their performance will be carried out as part of the piloting operation (see Volume 3, Part 1, Volume 1, Section 5, Page 5-12).

Request 63.5 On Page 5-8 referring to the proposed steam deaerator; *'At the proposed process conditions, no hydrocarbon vapours are expected to be drawn off with the air and water vapour.'*

Explain how Shell made this determination. What data does Shell have about the level of hydrocarbon emissions from existing deaerators that operate at 80 to 85 degree C?

Response 63.5 The final design of the deaerator process has yet to be confirmed. Options include mechanical, vacuum and steam deaeration. The preliminary design has a target temperature of 65°C (compared to current operations of 80°C to 85°C) and a partial vacuum. The system will be enclosed and will contain a condenser to remove water vapour. At the targeted operating temperature, minimal, if any, hydrocarbon vapours are expected. If hydrocarbon vapours are present with the water vapour, they will be condensed along with the condensed water and combined with the extraction tailings stream.

Shell has no information on hydrocarbon emissions from existing deaerators.

Request 63.6 The application states; *'The water vapour will be condensed and recycled for use in the process.'*

Explain how water vapour from the steam deaerator will be condensed and recycled. Where will condensed water be re-injected into the process? Will the water vapour recovery system be a closed loop? Has Shell considered mechanical de-aeration and its potential to reduce VOC, NO_x and GHG?

Response 63.6 The deaerator overheads will be passed through a condenser before reaching the vacuum pump. Any recovered water and any hydrocarbons will be collected and combined with the extraction tailings stream. Therefore, the recovered water from the deaerator will be part of the closed loop process water cycle from the tailings settling pond. Shell has considered mechanical deaeration as an option. No commercially proven methods are currently available.

If viable systems become available, Shell will have the opportunity to test mechanical deaeration in its piloting operations.

Request 63.7 On Page 5-6 the application notes that 1996 research shows that agitation tanks can accomplish similar conditioning to that of high-density hydro-transport of oil sands.

How does this compare in terms of energy inputs and air emissions?

Response 63.7 Other than the feed systems (i.e., cyclofeeder and rotary breaker) both the hydrotransport and the agitation tank systems will be enclosed and will have minimal, if any, air emissions.

Preliminary engineering comparisons of the agitation tank system with a 5 km hydrotransport system show the horsepower requirement for pumping the oil sand slurry in the hydrotransport pipeline to be greater than that required for tank agitation.

Request 63.8 Potential VOC emissions sources from the froth treatment process include - froth tank - decanter - filter – disc stack - tailings solvent recovery unit - first stage separator - second stage separator – solvent recovery unit - tailings settling pond - dilute bitumen storage - pipeline.

Explain the vapour recovery system in more detail and identify any uncontrolled sources other than the tailings settling basin.

Response 63.8 A comprehensive vapour recovery system has been planned. The froth treatment process will be enclosed, as will the dilute bitumen storage. The pipeline is not part of the Muskeg River Mine application.

Uncontrolled emissions other than the tailings settling basin and those caused through unforeseen mechanical or process upsets are not expected. A flare system will be installed to manage major process upsets in the froth treatment plant.

Details of other vapour recovery systems which might form part of the commercial design will be developed as part of the detailed design of the facilities. Generally, the process vessels will be connected to a vapour collection and recovery system, so that any venting resulting from process variations will be captured. The vented vapours and inert gas will be sent to a solvent recovery system, after which they will normally be recycled.

All storage tanks containing solvent will have internal floating roofs with double seals to prevent emissions.

Details of the pipeline design and environmental impact will be included in the pipeline application and Conservation and Reclamation Plan.

Request 63.9 Existing oil sands operators have found that virtually all of the VOC in the tailings will be released to the atmosphere through volatilization within a relatively short period of time.

Has Shell assumed that all VOCs released to the tailings will volatilize in estimating Muskeg River mine VOC emissions? What will be the VOC content of this tailings stream after the TSRU in tonnes per day? Has Shell speciated the tailings to determine the actual breakdown of VOC present?

Response 63.9 Shell has not assumed that all VOCs will be released. The VOC source is the froth treatment plant solvent which is lost to the tailings. Most of the solvent will be retained in the settled froth treatment plant tailings. The solvent content of the tailings stream is shown in the froth treatment plant material balance in Volume 1, Section 9 of the application and in the revised material balances in Section 4.3, Material and Energy Balances, in the Project Update. The VOCs will contain the same constituents as the froth treatment solvent, i.e., light paraffin hydrocarbons.

Request 63.10 The separator vessels will operate at 30 degree C to limit volatilization of the solvent, and they will also be blanketed with nitrogen under sufficient pressure to suppress solvent vaporization.

Will this effectively eliminate VOC emissions from this potential source?

Response 63.10 The separator vessels will be sealed to prevent solvent loss and air from entering. Pressurized nitrogen blanketing and the operating temperature of 30°C effectively remove the likelihood of VOC emissions.

Request 63.11 Discuss the pros and cons of nitrogen vs. methane as the stripping agent in the TSRU from an emissions point of view.

Response 63.11 The TSRU will be a sealed unit. Therefore, uncontrolled emissions are unlikely either from the use of nitrogen or methane. Nitrogen, if used for stripping, will be captured and recycled. Methane, if used for stripping, will be subsequently used as fuel gas for heating process water or for steam generation.

Request 63.12 The application states (Page 10-9) that NO_x emission mitigation strategies include low NO_x burners for the plant site and emission control technology for mine fleet vehicles.

Please provide more information about the type of low NO_x system being considered for burners, and the type of pollution control for vehicles, including emission rates.

Response 63.12 The type of low NO_x burner will be determined during detailed engineering design. For mine fleet emissions, see the response to AEP 18.

Request 63.13 What are the energy and emission intensities of the the proposed natural gas boilers and turbines?

Response 63.13 We are not clear what is meant by "emission intensities". However, the efficiency of the natural gas boilers is about 85%. There are no turbines identified in the application.

Request 63.14 Potential VOC emissions from extraction process include: - open face - truck bed - crusher - open conveyor - rotary breaker (80 degree C water added) - agitation tanks - primary separation vessel - flotation cells (air addition) - hydrocyclones - steam deaerator - froth tank - tailings settling pond. Shell assumes that there will be no significant emissions from the extraction process (Page E2-20).

Please explain the basis for this assumption.

Response 63.14 The open face and truck bed are not considered part of the extraction process. VOC emissions, if any, from these areas are expected to be similar to existing oil sand mining operations. As the mining activity is carried out at ambient temperatures, significant levels of VOC emissions are not expected.

The crusher and open conveyor are operated at ambient temperature and exposed surface area is limited. Therefore, the amount of VOCs emitted are not expected to be significant.

The agitation tanks, hydrocyclones, steam deaerator and froth tanks are enclosed vessels with control of emissions and capture of VOCs. VOC emissions from these vessels are expected to be insignificant, if any.

The rotary breaker, primary separation vessel, and flotation vessels are open to the atmosphere. The flooding of water in these vessels will help to contain VOC emissions. In the flotation cells, where air is added, there are only small quantities of bitumen remaining, thus minimizing the amount of air-bitumen contact.

Request 63.15 The transportation diluent pipeline is one of the components of this Project.

Is Shell going to submit a separate application and EIA for their two pipelines? What is the capacity of the diluent pipeline and the dilbit pipeline?

Response 63.15 Shell will be making a separate application to the EUB and AEP for the corridor pipeline. The corridor pipeline right-of-way will contain two pipelines in a common ditch:

- a 24-inch line to transport diluted bitumen from the Muskeg River Mine to the upgrader at the Scotford complex near Fort Saskatchewan
- a 12-inch line to return diluent from the upgrader to the mine

The 24-inch dilbit pipeline could handle up to 350,000 bbl/d. The 12-inch line could handle 100,000 bbl/d.

Details of the pipeline design and environmental impacts will be included in the pipeline application and Conservation and Reclamation Plan.

Question No. 5.2 (30)

Shell No. OSEC 64

Issue **Energy Use - Additional Energy Demand**

Request The Oil Sands Environmental Coalition wishes to ensure that Shell has not overlooked some energy efficient options for processing or for producing heat or electricity.

64.1 The application notes that Shell is considering on-site power generation.

Please provide an update on Shell's assessment of this option including a detailed breakdown of overall emissions of GHG, NO_x, etc.

Response 64.1 Shell is continuing to evaluate the opportunity for onsite cogeneration of electrical power and heat. The two options being considered are:

- electrical demand balance – providing supplementary heat energy to the process
- heat energy balance – providing additional electrical energy for sale to the provincial grid

The level of overall greenhouse gas emissions from cogeneration is expected to be lower than the option presented in the application.

Request 64.2 Shell indicates that there is a potential for a power and utilities cooperative with Syncrude's Aurora Mine project.

Please provide OSEC with an update on the progress of these discussions with Syncrude.

Response 64.2 Joint evaluation of the potential for a power and utilities cooperation arrangement with Syncrude's Aurora project is ongoing (see Section 1.2, Regional Cooperation, and 4.1, Utilities and Offsites, in the Project Update).

Request 64.3 There may be excess low-grade steam left over after all other uses that would normally be released to atmosphere. Low-grade steam may be used for area heating of buildings.

What opportunities exist for the use of low-grade steam for area heating at the proposed facility?

Response 64.3 There are no sources of low-grade steam available from the utility configuration outlined in the application.

Request 64.4 All investments in energy efficiency are normally evaluated against some form of rate of return requirements that the company has. It is important for us to understand Shell's 'hurdle rate', or the rate of return that is considered necessary in order for any investment to be considered economical, for energy efficiency options.

Please discuss Shell's rate of return requirements on energy efficiency with respect to heat generating, electrical generating, mobile equipment, and processing equipment for the Muskeg River Mine.

Response 64.4 Shell is not in a position to discuss the financial criteria it uses for decision making.

Question No. 5.3 (31)

Shell No. OSEC 65

Issue Water Use

Request The Oil Sands Environmental Coalition is concerned that the water withdrawals from the Athabasca River for the Project, in combination with other existing and approved (or planned) projects will have a negative impact on the flows of the River.

The EIA (pg. F4-15) predicts that net water allocation will result in the reduction of Athabasca River flows as much as 4.3% in the winter. This percentage can be expected to increase with increasing oil sands development in the area, and also increase during drought-like conditions. Reduction in flow volume of the Athabasca over a long period of time can lead to changes in vegetation patterns and water bodies in proximity to the main channel, as well as impacts on downstream ecosystems.

Response The Muskeg River Mine Project alone would result in declines in mean Athabasca River flow of less than 0.5% during all open water seasons (see EIA Volume 4, Table F4-14). Flow reductions from existing developments and the Muskeg River Mine Project together have been calculated to be less than 1% during spring and summer and about 2% during the fall. When planned developments are added, spring and summer flow reductions would still be less than 1% and about 2.4% in the fall (see EIAVolume 4, Table G4-15). These fluctuations would not be measurable and would fall within the natural variability of the existing flow regime.

The reduction in water flows at less than 1% or 4.3% levels in the winter would not affect vegetation. Only flow changes during the open water seasons would be expected to affect vegetation.

Question No. 5.4.1 (32)

Shell No. OSEC 66

Issue Tailings – Contamination from Consolidated Tailings

Request The Oil Sands Environmental Coalition is concerned that the Consolidated Tailings technology for disposing of oil sand tailings will produce unacceptable impacts in the environment, and that the process and by-products are not well understood.

66.1 Mature fine tailings will be pumped into the end-pit lake and left as part of the final reclaimed landscape. We are concerned about the relative ease which toxicants can move from a fluid fine tails (in a capped pond) up into the overlying water layer, relative to emissions from any of the dry tailings alternatives. The toxic constituents of the tailings may impair the ecological sustainability of the end-pit lake by exposing the lake ecosystem (which we expect to be fragile as it is) to tailings chemicals. All tailings should be incorporated into the consolidated tailings process.

Response 66.1 CT production requires fresh tailings during operations so that cycloned sand is available to mix with mature fine tailings and gypsum. Therefore, it is not practical or economical to produce CT after operations. Research at Syncrude's Base Mine Lake will verify the viability of mature fine tailings in end-pit lakes.

Request 66.2 Mature fine tailings additions to the end-pit lake will result in a pulse of end-pit lake water to be released to the Muskeg River in approximately 2030. If mature fine tailings additions are permitted into the end-pit lake, they should occur at a rate which does not cause any release flow disturbance.

Response 66.2 Initial high end-pit lake releases (up to 1.5 m^3/s) will occur from 2028 to about 2033. Shell is prepared to direct portions of the end-pit lake flow as might be required to the Athabasca River to ensure that the quality of the Muskeg River water is protected. If all of the flow were directed to the Athabasca River, water quality guidelines would be maintained within acceptable levels within regulatory mixing zones (see Section 7.1, End-Pit Lake Discharge, in the Project Update).

Request 66.3 Byproduct Mineral Recovery is discussed on Page 5-13 of the application.

Describe the conventional practice for extracting titanium and zircon. What impact would this process have on tailings impoundment design features and CT potential?

Response 66.3 The conventional extraction of titanium and zirconium minerals is undertaken on beach sands in various parts of the world. The technology used involves heavy media separation tanks and magnetic separators. These methods cannot be directly applied to recovering these minerals from process streams in oil sands extraction. These minerals tend to concentrate in the froth treatment tailings which are much finer than beach sands. The process suggested for the recovery of minerals from such a stream involves flotation, heavy media separators and magnetic separators and is more complex than with beach sands. Such a process has not been commercially developed for oil sands.

Extraction of these minerals would reduce the volume of tailings, but clays would remain. There will be minimal impact on process tailings, impoundment design and CT potential.

Request 66.4 The Application (pg. 6-11), refers to a 'fall back plan' for disposal of tailings. Wet capping of tailings ponds is proposed as the contingency reclamation technology while several dry tailings alternative remain available. Even a combination of alternative (non-CT) dry tailings sites with wet cap ponds might be preferable to complete wet-cap reclamation.

Discuss what other methods will be investigated. What is the schedule of research?

Response 66.4 The fallback plan suggested by Shell is based on an approved approach which has been developed following a substantial amount of research and testing, particularly by Syncrude. Shell is not willing to suggest an alternative plan, which might be conceptual in nature, at this stage.

The application reviews a number of tailings management alternatives that have been evaluated as part of preliminary engineering.

The pilot plant will enable Shell to test the characteristics of tailings produced from a non-caustic extraction process. It is proposed to do this through a series of beaching and settling tests.

The piloting of the non caustic process will be carried out during 1998 and 1999. Shell has also entered into a cooperative arrangement with Syncrude and Suncor that will provide for sharing technical information in the piloting, development and commercialization of tailings management techniques involving paste and CT technologies.

Once the characteristics and behaviour of non caustic tailings are well understood, Shell will look for opportunities to use these characteristics in its tailings management plan.

Question No. **5.4.1 (32)**

Shell No. **OSEC 67**

Issue **Tailings – Contamination from Consolidated Tailings**

Request The Oil Sands Environmental Coalition is concerned with the potential for impact on aquatic and semi-aquatic vegetation by the CT water in the proposed end-pit lake.

67.1 The application states that upland reclamation communities on the south shore of the end-pit lake are not expected to be impacted by the CT water in the end-pit lake.

Provide the rationale for this conclusion.

Response 67.1 As discussed in EIA Volume 3, Part 1, page E5-36, the water quality of the end-pit lake will be non-toxic by the time it reaches discharge level and will have no potential to affect upland vegetation. For additional details on the water quality associated with the end-pit lake as it fills and discharges, see the response to AEP 105.1.

Request 67.2 EIA discusses in several places how reclaimed wetlands will be used for bio-remediation of CT release water. The EIA also discusses the potential for the release of CT water with elevated levels of salinity and other chemicals (E16-36).

Please discuss how CT release waters will affect the health of vegetation and wildlife using these wetlands?

Response 67.2 See the response to OSEC 44.8.

Question No. **5.4.1 (32)**

Shell No. **OSEC 68**

Issue **Tailings - Contamination from Consolidated Tailings**

Request The Oil Sands Environmental Coalition is concerned with the potential impacts of CT water on reclamation terrestrial vegetation communities.

68.1 The application states that due to the high degree of variability of CT water, and lack of information on the effects of CT water on plant communities, the impact of CT water on reclamation vegetation communities is unclear.

Describe how the proponent intends to carry out research and monitoring to address these uncertainties.

Response 68.1 See the response to OSEC 44.8. See also the response to AEP 35 on Shell's Monitoring Committee.

Request 68.2 What plans does Shell have for a reclamation contingency plan for how they would proceed with reclamation under those conditions if CT water turns out to have a negative impact on the health of reclamation vegetation communities?

Response 68.2 Ongoing CT research will determine what adaptive management strategies will be implemented, if necessary.

Request 68.3 The CT research appears to be focused only on the higher order plants and animals (i.e. macro-fauna & -flora), and excludes the microbial level. These organisms are important to the establishment of the successful CT landscape and should be included in the research and monitoring.

Response 68.3 Shell is currently participating in an extensive CT research program through CONRAD. The nature of these studies will evolve over time, depending on the results of the initial programs. Consideration will be given to microbial level organisms in the future.

Question No. 6.1 (33)

Shell No. OSEC 69

Issue **Third-Party Bitumen Processing**

Request

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

69.1 Elaborate on why this approval is being sought.

Response

69.1 See the response to EUB 2.

Request

69.2 What volumes are being considered?

Response

69.2 See the response to EUB 2.

Request

69.3 How will waste transfers be handled?

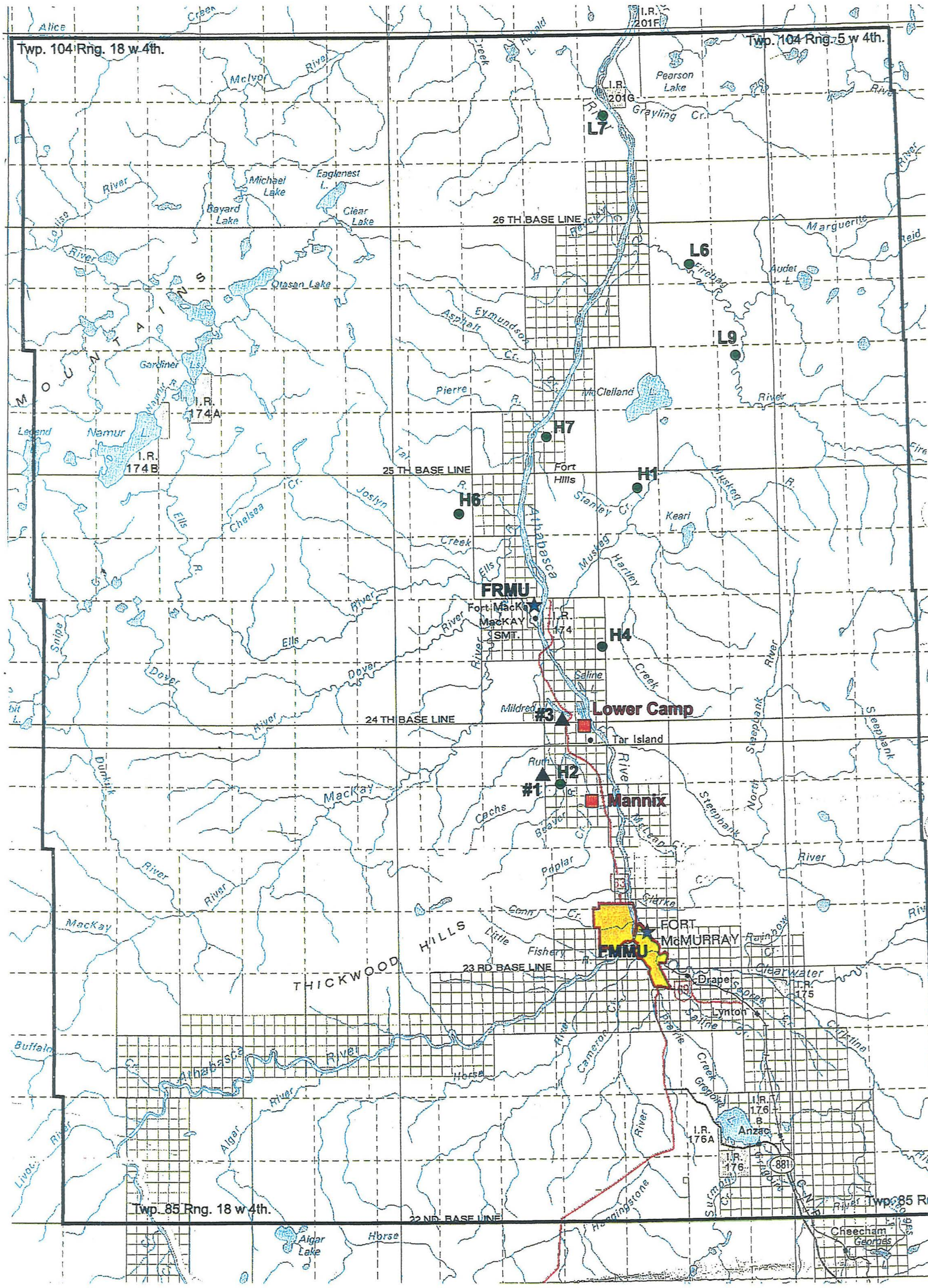
Response

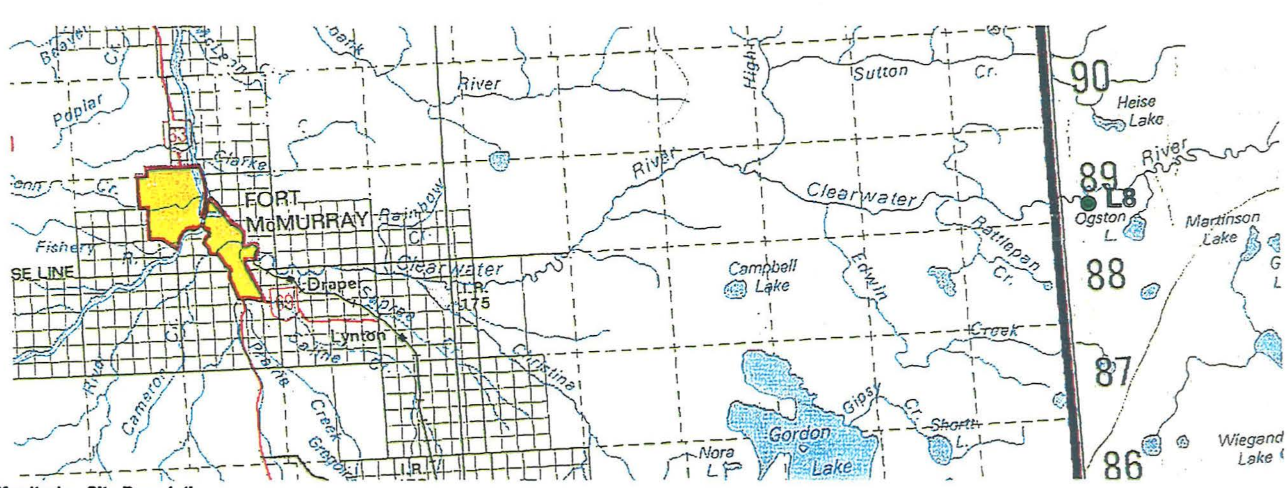
69.3 See Volume 1, Section 16.2 for a discussion on waste management. The Class 2 landfill, which will be constructed on site, is described in Section 6.2 of the Project Update. A hazardous waste storage area and a recycled waste storage area will be developed to provide interim storage for waste that is unsuitable for the Class 2 landfill. Licensed hazardous waste and recycling contractors will remove the waste from the site in accordance with Alberta Waste Control Regulations and Transportation of Dangerous Goods (TDG) Regulations.

Attachment 1

Historical SO_2 Emissions in the RSA

Year	Suncor Powerhouse FGD	Incinerator	Flaring	Subtotal	Syncrude Main	Diverter	Flaring	Subtotal	Total
1967	0	0	0	0	0	0	0	0	0
1968	132	0	0	132	0	0	0	0	132
1969	153	0	0	153	0	0	0	0	153
1970	193	0	0	193	0	0	0	0	193
1971	208	0	0	208	0	0	0	0	208
1972	217	52	0	269	0	0	0	0	269
1973	222	52	0	274	0	0	0	0	274
1974	213	37	12	262	0	0	0	0	262
1975	213	25	12	250	0	0	0	0	250
1976	221	25	5	251	0	0	0	0	251
1977	200	21	4	225	0	0	0	0	225
1978	205	17	3	225	70	0	0	70	295
1979	207	21	3	231	19	0	0	19	250
1980	231	27	5	263	141	2	15	158	421
1981	166	19	13	198	189	5	38	232	430
1982	137	21	64	222	111	4	23	138	360
1983	139	24	35	198	157	4	28	189	387
1984	153	30	43	226	161	4	4	169	395
1985	154	28	35	217	226	1	3	230	447
1986	160	28	27	215	228	2	2	232	447
1987	159	20	13	192	227	1	11	239	431
1988	180	27	20	227	199	2	2	203	430
1989	172	33	16	221	189	2	3	194	415
1990	164	24	7	195	194	1	10	205	400
1991	175	26	6	207	203	1	8	212	419
1992	182	25	6	212	225	1	7	233	445
1993	196	24	6	226	213	2	5	220	446
1994	211	30	7	248	226	1	3	229	477
1995	215	16	3	234	205	1	2	207	441
1996	155	18	27	200	197	0	2	199	399
1997	27	18	27	72	193	0	1	195	271
Mean	179	26	17	222	179	2	9	190	412
Years	30	26	24		20	18	18		
Total (kt)	1956	251	146	2353	1304	13	61	1378	3731
Plant (%)	83.1	10.7	6.2	100	94.7	0.9	4.4	100.0	
Total (%)	52.4	6.7	3.9	63.1	35.0	0.3	1.6	36.9	100.0
1990-1997	166	23	11	199	207	1	5	212	412
Plant %	83.1	11.4	5.6	100	97.4	0.4	2.2	100.0	
Total %	40.2	5.5	2.7	48.3	50.2	0.2	1.2	51.5	100.0





Legend

- ● Jack pine sites in (L)Low and (H)High deposition zones.
- ■ Suncor Monitoring Stations
- ▲ Syncrude Monitoring Stations
- ★ Alberta Environmental Monitoring Stations

Monitoring Site Description

Monitoring Location	Continuous										Intermittent					Passive			Deposition		Biomonitoring		
	SO_2	O_3	H_2S	NOx	PM_{10}	THC	TRS	Wind	Temperature	Intensive meteorology	PM_{10}	$PM_{2.5}$	VOC's	PAH's	Metals	O_3	NO_2	SO_2	Wet / weekly	Dry / every 6th day	Soil Acidification	Vegetation acidification	Tree health
H1, H7, L6, L7, L8, L9																					x	x	x
H2, H4, H6																x	x	x			x	x	x
Lower Camp	x		x			x		x										x					
Mannix	x		x			x		x										x					
#1	x		x			x		x										x					
#3	x		x			x		x										x					
FRMU	x	x		x	x	x	x			x	x	x	x	x	x	x	x	x	x	x			
FMMU	x	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x					

Scale 1:750 000

AGRA Earth & Environmental ENGINEERING GLOBAL SOLUTIONS	CLIENT: Wood Buffalo Environmental Association	DATE: FEB. 1998
	PROJECT: Terrestrial Environmental Effects Monitoring	JOB No.: CC01142.5000
	WOOD BUFFALO AIR EMISSION MONITORING LOCATION	COREL FILE: 01142E02
		FIGURE 1 REV. -

MUSKEG RIVER MINE PROJECT
Information Request

EUB No.	Exhibit No.
Information Requested By: ENVIRONMENT CANADA	
Date of I.R. June 23, 1998	

Question No. 1

Shell No. EC 1

Issue **Emission Sources**

Request

Fugitive sources of air emissions have been identified for non-combustion sources only (E2-9). Small generators, engines and machinery may also be potentially significant sources but it is not clear whether these have been included in the assessment. Given that NO_x and CO_2 are primary emissions of greatest concern, controlling low efficiency engines may prove to be an important step in decreasing ambient concentrations of nitrogen oxides and greenhouse gas emissions. All sources of fugitive emissions should be incorporated into the assessment of effects on air quality. Opportunities for reducing ambient concentrations of NO_x and greenhouse gas emissions should consider all sources, not only major combustion sources.

Response

Small NO_x emission sources (e.g., small engines, light-duty vehicles) have not been included in the EIA. At this stage, the engineering design is not sufficiently advanced to identify or quantify these small sources. Shell proposes to use electrically driven pumps where possible and generators will only be used in a standby mode. Light-duty vehicles will have standard emission controls.

The mine fleet exhausts have been identified as the major sources of NO_x and CO_2 emissions associated with the Muskeg River Mine Project. Other sources are expected to be comparatively small. Shell will ensure that emission considerations are addressed during the design stage for these minor sources.

Question No. 2

Shell No. EC 2

Issue **Emission Sources**

Request

Primary emissions of particulate matter (PM) have been predicted using stationary source emission factors from the U.S. EPA (E2-9). The accuracy of these factors should be validated through a comparison of the predicted emissions with the actual ambient concentrations for the facility, and the region, after the project goes into operation.

Response PM emission estimates were based on both stationary and appropriate off-road mobile source factors. EIA Volume 3, Part 1, Section E2.3.6 identified the need for an ambient air quality monitoring program to measure PM_{10} and $PM_{2.5}$ in the vicinity of the mine. The information from this program would complement similar data collected in Fort McKay by the recently upgraded Wood Buffalo Environmental Association monitoring program.

Question No. 3

Shell No. EC 3

Issue **Emission Sources**

Request Primary emission factors were not used for mining operations because they were deemed insignificant based on the experience at the Syncrude and Suncor mines (E2-15). No fine PM concentrations were shown for either of these mine sites. Primary emissions factor estimates for the facilities, vehicles and mines, must be validated for, site specific conditions and the region. This is essential for future cumulative assessments.

Response Shell did not intend to indicate that fugitive PM emissions from mining operations would be insignificant. The EIA indicated that the use of available fugitive PM emission factors based on Western U.S. surface coal mines are not appropriate for oil sands mining operations. The EIA further stated that there are methods to control fugitive PM emissions and that ambient PM_{10} and $PM_{2.5}$ monitoring would be conducted in the vicinity of the mine (see the response to EC 2). This monitoring would measure PM concentrations that result from combustion sources as well as from fugitive sources.

Question No. 4

Shell No. EC 4

Issue **Emission Sources**

Request The quantity of "unknown" emissions of total hydrocarbon (THC) and total reduced sulfur (TRS) (tables in section E2) are significant at both the mine surface and tailings ponds. These high levels of unknown emissions make it difficult to estimate the ozone-producing potential of the project. This uncertainty must be considered when evaluating the ozone producing potential of the project.

Response See Sections 7.3 (Ozone Formation) and 7.4 (Volatile Organic Compound Emissions) that discuss revised VOC emissions and provide initial ozone predictions based on the CALGRID model, respectively.

Question No.	5
Shell No.	**EC 5**
Issue	**Emission Sources**

Request

The ozone producing potential has been estimated to be near 82 ppb based on regional NO_x and VOC emissions (E2-53). This estimate does not reflect the potential contribution of VOCs from natural sources which could also be significant due to the forest and peatland in the region. Increased temperatures and photosynthetically active radiation (PAR) during summer months will increase the facility and natural VOC emissions. The ozone producing potential of the project should be evaluated under these worst case scenario conditions. Given the uncertainties regarding the facility VOC, THC and TRS emissions, and the contribution of natural VOC emissions, it is very important that a monitoring and emission measurement program be implemented to verify model predictions and assumptions. This will assist in predicting and understanding the ozone producing potential from the project and for the CEA.

Response

The SMOG model predictions provided in EIA Volume 3, Part 1, page E2-54, included biogenic emissions as well as anthropogenic sources of VOC values. Section 7.3 (Ozone Formation) in the Project Update provides initial ozone predictions based on the CALGRID model. The CALGRID modeling also included biogenic VOC emissions. Shell will conduct fugitive emissions inventories of the Muskeg River Mine facilities. Shell also will be an active participant in the Wood Buffalo Environmental Association which is currently implementing the regional ambient air quality monitoring program. Ozone concentrations is one of the parameters being recorded at the ambient air monitoring stations.

Question No.	6
Shell No.	**EC 6**
Issue	**Modelling and Evaluation of Ambient Concentrations**

Request

For the ISC3BE model, changes were made to ISCST3 so that it would more accurately predict the parameter of the total number of exceedances of the 0.17 ppm ambient guideline for hourly SO2 concentrations. The results in Table II-2, Volume 2 raise concerns regarding the effect of these changes on the prediction of regional patterns. While both models overpredicted the total number of exceedances for all monitoring sites, this was not the case for the monitoring stations in nearby communities. For Fort McKay and Fort McMurray, actual observations showed a total of 5 exceedances of the 0.17 ppm guideline. This was the number of exceedances predicted by ISCST3, while ISC3BE did not predict any exceedances in those communities. When changes are made to models, they should improve overall model performance parameters such as total exceedances or projected maxima, but model results must also be examined at the issue or site specific level as well. In this case, changes to the ISCST3 appeared to also affect the pattern of predicted exceedances so that it underestimated the effects within local communities, where there is likely the greatest health related concern about exceedances.

Response

Modifications were made to ISCST3 to better predict the magnitude of high SO_2 concentrations, the frequency of these high values and the diurnal distribution of these values. The ISC3BE model was deemed to be more realistic than the unmodified ISCST3 model. However, the differences between these two models is less than the differences that were noted with earlier versions of the ISC model (e.g., ISCST2).

Because the ISCST3 model predicts five exceedances in these communities does not make it a better model. Note that ISCST3 predicts four exceedances in Fort McKay where only one exceedance was observed. Both models will be challenged to correctly predict exceedance values, as average emission data were used that did not account for hourly variability associated with normal emissions and abnormal upset events were not considered. Shell concludes that the ISC3BE model is providing reasonably realistic model predictions, given these limitations.

Near mine sources, both the ISCST3 and the ISC3BE model predictions are virtually identical. This is the location where the maximum values from these sources are predicted to occur.

Question No. 7

Shell No. EC 7

Issue **Modelling and Evaluation of Ambient Concentrations**

Request

The discussion of the NO and NO2 concentration estimates states that increasing NO emissions will reduce the amount of O3 downwind because NO is converted to NO2 by reaction with O3 (E2-27). NO oxidation occurs readily in ambient air since the atmosphere has many oxidizing agents including OH, NO, HO2, H2O as well as O3. Therefore increased NO may or may not be available to react with downwind O3. Because of the number of uncertainties and assumptions made within the modeling predictions and equations, it is very important that the concentrations of NO and NO2 be confirmed through monitoring near and around the new facilities. The maximum hourly and daily average NO2 concentrations which are predicted to double from this development alone, should be confirmed through sampling. The Southern Wood Buffalo Air Management Zone is switching to more chemically and meteorologically sensitive models such as CALGRID for assessing cumulative effects. While this does not remove the requirements for model validation through monitoring and sampling, this initiative should improve the modeling prediction capabilities for the region.

Response

EIA Volume 3, Part 1, Section E2.3.6, identified the need for an ambient air quality monitoring program to measure NO_x (i.e., NO_2 and NO) in the vicinity of the mine. The information from this program would complement similar data collected by the Wood Buffalo Environmental Association monitoring program.

Question No. 8

Shell No. EC 8

Issue **Modelling and Evaluation of Ambient Concentrations**

Request

Ozone levels in the region are of concern. In the CEA, the simplistic assessment on page F2-4 of increased NO_x concentrations being linear with emission estimates is reasonable for zeroth order, but this is not acceptable for an overall consideration of the NO_x/VOC/O3 cycle in the region. These chemicals interact differently at different concentrations. The region may alternate several times between NO_x-limited and VOC-limited depending on the season or other emissions in the region. This process will also affect O3 concentrations. The EIA modeling results indicate that the oil sands region can expect exceedances of the 82 ppb O3 guideline. This makes the Fort McMurray region one of the only areas in western Canada where ozone exceedances are expected. While modeling is an important tool for predicting concentrations, it is not considered to be a mitigation option where exceedances occur. Predicted O3 concentrations must be confirmed through sampling. Mitigation options to address guideline exceedances should be included in the EIA.

Response

More refined ozone modeling predictions for the Regional Study Area are provided in Section 7.3 (Ozone Formation) in the Project Update. Air quality monitoring programs to measure O_3, or the potential precursors to ozone, (i.e., NO_x and VOC), are discussed in the responses to EC 5 and EC 7. The Muskeg River Mine Project is expected to increase regional ozone concentrations by less than 1%. Mitigation options to address exceedances of ozone in the region, as reflected in the CEA, would need to be addressed by members of the Wood Buffalo Environmental Association.

Fort McMurray is not the only area "in Western Canada where ozone exceedances are expected". Ozone exceedances are expected in other areas of Alberta based on historical monitoring. The following references identify locations and associated maximum one-hour average ozone concentrations that have been observed. Angle and Sandhu (1986) identified exceedances of 82 ppb at Birch Mountain (120 ppb), Bitumount (130 ppb), Ellerslie (122 ppb) and Joffre (135 ppb). Angle and Sandhu (1989) identified exceedances of 82 ppb at these same stations as well as in Edmonton (86 ppb) and Calgary (88 ppb). Peake and Fong (1990) identified exceedances of 82 ppb at Fortress Mountain (122 ppb). Cheng et al. (1998) attributed exceedances in Edmonton (92 ppb) and Fort Saskatchewan (92 ppb) to a forest fire in NE Alberta.

Question No. 9

Shell No. EC 9

Issue **Modelling and Evaluation of Ambient Concentrations**

Request

Secondary pollutants such as fine particulate matter (PM10 and PM2.5) and ozone need to be fully considered in the assessment. Secondary PM does not appear to have been completely addressed in the calculations, monitoring programs or mitigation measures described. The footnotes of Table D2-7 identify the PM10 and PM2.5 guidelines as being only for primary PM emissions, but these guidelines include secondary PM. Therefore the allowable concentration of PM from primary emissions, will actually be some fraction of the referenced guideline number. Because the projected PM concentrations in the EIA (Table D2-7) only represent primary emissions, only a fraction of the total PM expected has been accounted for.

Measured information on PM10 shows exceedances of some guidelines in Fort McMurray. Hourly values range from 11.8 to 105.5 ug/m3 (D2-36). While these values are within the United States Environmental Protection Agency (EPA) guideline of 150 ug/m3, they exceed British Columbia and Ontario guidelines (50 ug/m3). It should be noted that the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines has recommended values for national ambient air quality objectives for these species. Currently under review, the 24-hour averages proposed as national guidelines are 25 ug/m3 for PM2.5 and 40 ug/m3 for PM10. Secondary pollutants, particularly fine PM and O3, need to be further characterized in the region through a combination of modeling and monitoring. Preliminary results presented in the EIA indicate that mitigation options for secondary pollutants need to be considered as exceedances are expected.

Response

The concentrations of the secondary particles, sulphate and nitrate, have been calculated using the CALPUFF model. As the Muskeg River Mine Project will not be a source of SO_2 emissions, there will not be any changes to the predicted sulphate concentrations as a result of the project. The maximum predicted nitrate concentrations resulting from the project are predicted to double in Fort McKay (from 6 to 13 $\mu g/m^3$) and increase by 4% (from 3.5 to 3.6 $\mu g/m^3$) in Fort McMurray. As these are intermediate prediction results, Shell views them as preliminary, subject to confirmation through monitoring.

The primary emission from the Muskeg River Mine Project with the potential to form secondary particles is NO_x emissions from the mine fleet exhausts. Shell will consider the emission controls available on these types of vehicles when making purchasing decisions.

In addition, the enhanced Wood Buffalo Environmental Association monitoring program is collecting data on PM_{10} and $PM_{2.5}$. An analysis of this data will allow differing types of sources to be identified.

AEP recently started collecting hourly PM_{10} data in Fort McMurray. Comparison of peak hourly values to 24-hour guidelines is somewhat questionable as all the PM_{10} health correlations have been based on 24-hour average exposures.

At this stage, it is premature to consider recommended guidelines for PM_{10}, $PM_{2.5}$ and ozone, as the final values might be different from the proposed values (based on U.S. experience).

Question No. 10

Shell No. EC 10

Issue **Effects Due to Changes in Air Quality – Health Effects**

Request

There has been no calculation of secondary PM and its influence on respiratory health in the region. Measured PM levels in Fort McMurray (D2-36) are near and above levels being considered for new Canada Wide Standards *(reference number?). Projected levels for Fort McKay (E12-34) do not include any secondary PM contribution and are already near Health Canada's recommended level of 15 ug/m3.* Respiratory issues may become an emerging issues for regional residents. As noted previously, modeling results are preliminary for PM, O3 and NO_x. Monitoring programs and mitigation strategies are required for these parameters. Health Canada should be consulted on the requirements for mitigation measures, particularly for Fort McKay where PM, O3 and NO_x could be elevated above guidelines.

Response

The Wood Buffalo Environmental Association monitoring program has enhanced the parameters that are collected in Fort McKay based on human health concerns. A review of the data with all stakeholders, including Health Canada, will allow current source contributions to be evaluated and mitigation to be developed, if necessary. The first review of these enhanced data will best be undertaken after the first full year of collection.

Question No. 11

Shell No. EC 11

Issue **Effects Due to Changes in Air Quality – Health Effects**

Request

The health assessment does not address atmospheric concentrations of metals, although it is recognized on page E12-34 that the atmospheric component is unknown at this time. Monitoring should be implemented to determine if there is a residual inhalation component on the particulate matter. Health Canada should be consulted on the requirement for monitoring and mitigation considerations for atmospheric metals.

Response

No significant metal emissions are expected to occur from the Muskeg River Mine Project.

Question No. 12

Shell No. EC 12

Issue **Effects Due to Changes in Air Quality – Health Effects**

Request

Base cation concentrations observed in the Fort McMurray region are quite high when compared with accepted provincial background stations (D2-38). As a result, acidifying emissions have not been considered as a potential health concern because it is assumed that they will be neutralized. While base cations do neutralize acidity, these high concentrations of base cations may be from the PM emissions. Recent literature shows that it has not been determined whether observed health effects result from acidity or the size of the PM (NRDC, 1996). It is not acceptable to rely upon elevated base cation concentrations to negate effects on human health, as risks to health from PM may be considerable. This issue should be addressed in the EIA.

Response

The relatively high inferred base cation concentrations based on Fort McMurray data were corroborated by the corresponding values for Fort Chipewyan. The base cation concentrations reported in EIA Volume 2, page D2-38, are significantly lower than any PM guideline values.

Question No. 13

Shell No. EC 13

Issue **Ecosystem Effects**

Request

One of the emerging issues for the oil sands region is the increase in NO_x emissions which will contribute to nitrogen deposition to soils and water bodies, and enhanced ozone production. This issue has not be dealt with consistently in the EIA, and in particular the assessment of its effects on soil and water acidification. The soil acidification section (E8-12) states that the project will produce no sulphur emissions and negligible levels of NO_x. This statement is contradictory to the information presented in Table 2-23, which indicates that the existing potential acid input (PAI) is 0.20 keq/ha/a and that the project will contribute a maximum of 0.45 keq/ha/a resulting in a combined maximum of 0.55keq/ha/a. It needs to be confirmed whether analysis of the effects on soil and water acidification assumed 'negligible' levels of NO_x or the predicted concentrations.

Response

Soils

There is an error in EIA Volume 3, Part 1, Section E8.6.6, paragraph 1, where the statement is made that NO_x emissions will be "negligible". This is corrected in paragraph three further down on page E8-12 where values consistent with those in Section 2, Table 2-23, are quoted. It is these values, and not "negligible" levels, that were used in subsequent analyses of potential soil acidification impacts.

Water Quality

Analysis of surface water acidification used modeled PAI values, which incorporated NO_x levels.

Question No. **14**

Shell No. **EC 14**

Issue **Ecosystem Effects**

Request

While the use of the interim Critical Load of 0.25 keq/ha/a for acidic deposition is intended for large scale considerations, it is appropriate to use this load at a local level because it is based on the intrinsic properties of the soil. It has been identified that while SO2 deposition is not increasing (D2-56), NO_x deposition is increasing substantially leading to exceedances of the Critical Load. Near the vicinity of the Muskeg mine, levels will be above 0.50 keq/ha/a. Although there is no area within the CEA that is predicted to experience a loading of greater than 1.0 keq/ha/a, approximately 30 km2 will exceed 1.0 keq/ha/a in the RDR (Regional Development Review). Modeling also indicated that 40% of the RDR will have loadings greater than 0.25 keq/ha/a.

Soil sensitivity to acid deposition must be considered when evaluating the effects of the loadings from the project, and within the CEA. The soils are identified as acid-sensitive in the currently accepted system, however, most of the area is organic in nature and therefore there is uncertainty regarding soil sensitivity. The conclusion in the EIA that the soils in the area are highly to moderately sensitive is appropriate.

The 1.0 keq/ha/a loading is the level selected for the protection of the least sensitive soils therefore this loading rate may not be acceptable for high to moderately sensitive soils. The EIA recommends that more modeling is required. Given the predicted loading and soil sensitivity scenarios, more modeling is not sufficient. Mitigation options should be developed and presented in the EIA.

Response

The main source of acidifying emissions from the Muskeg River Mine Project is NO_x from the mine fleet. As indicated in the response to EC 18, Shell will continue to examine methods to reduce the sources of NO_x from the Muskeg River Mine Project. Shell can only recommend mitigation for its own facility, not for other operators.

Question No.	**15**
Shell No.	**EC 15**
Issue	**Ecosystem Effects**

Request

The Firebag, Steepbank and Muskeg Rivers have been defined as acid-sensitive and it is assumed that there are other water bodies in the region with similar sensitivities especially during the spring flush (E5-42). Environment Canada concurs that this issue needs additional study. However, this further highlights that there is a need to develop mitigation measures to address acidic deposition.

Response

As indicated in the response to AEP 33, the results of the spring pulse monitoring program on the Firebag, Steepbank and Muskeg rivers for changes in pH have been variable over the past three sampling years. Therefore, AEP is continuing sampling in 1999. However, as indicated in the response to EC 18, Shell will continue to examine methods to reduce the sources of NO_x emissions from the Muskeg River Mine Project.

Question No.	**16**
Shell No.	**EC 16**
Issue	**Greenhouse Gases and Climate Change**

Request

The scientific community has stated that there is a discernible human influence on global climate. The fact that the climate will change is generally accepted but there is debate on the magnitude, rate and significance of the projected changes (Intergovernmental Panel on Climate Change, 1995). Achieving Canada's recent Kyoto commitment to reducing its greenhouse gas emissions will require participation of all existing and new facilities and operations.

The oil sands region contributes 11,500 Kt/a, representing 6% of Alberta's total (D2-57). The Shell Muskeg River Project will add an additional 5,602 t/d (E2.7.1) or another 2,045 Kt/a. While projected greenhouse gas emissions are lower than other synthetic crude producers, more specific opportunities for pursuing additional reductions should be developed and presented in the EIA. These should reflect consideration of best available technology and continuous improvement, and eventual inclusion in Shell's VCR.

Response

The warm water extraction process currently proposed by Shell uses less energy than the Clark hot water processes presently being used by oil sands operators. In addition, the Shell process does not use chemicals (caustic) to aid in extracting bitumen, thus providing other environmental advantages. Table 16-1 compares CO_2 emissions associated with the hot water processes currently in operation and the Shell proposed warm water process. These figures are approximate, because the amounts can vary depending on the degree of process heat integration, summer and winter cases, and final technology arrangement.

Table 16-1: Comparison of Hot Water and Warm Water Processes

Technology	CO_2 produced (t/d) (based on a 150,000 bbl/day bitumen production facility)
Clark Hot Water Process (80°C)	3,658
Shell Warm Water Process (45 to 50°C)	3,049

Furthermore, Shell's commitment to the Voluntary Climate Challenge and Registry Program has been to achieve stabilization of Shell's CO_2 and total greenhouse gas emissions at 1990 levels by the year 2000 based on the 1994 level of business activity. This has led to continuous improvement in the energy efficiency of Shell's oil and gas production facilities as well as improvements in energy efficiency in the refining and manufacture of oil products.

Shell believes that the oil sands will provide Canada with a secure source of affordable energy supply for the next 20 to 30 years, in the face of declining conventional reserves. Athabasca oil sands are competing with imported crudes in the North American market. The CO_2 associated with the production of 150,000 bbl/d of synthetic crude from the Athabasca oil sands is less than the CO_2 produced from the partial upgrading and transportation of Venezuelan crude to North America, which is the fastest growing alternative.

The Muskeg River Mine Project will increase the overall greenhouse gas emissions for Shell, because of the growth in Shell's production. Shell is committed to continuously improving the energy efficiency of the proposed bitumen production facility and the proposed Scotford Upgrader facility in an effort to reduce greenhouse gas emissions. Targets will be set for these facilities and incorporated into the Voluntary Challenge Program. In addition, Shell's oil sands facilities will be compared with imported crudes on a full cycle basis to ensure that the CO_2 associated with the production, shipping, and refining of oil sands products is competitive with imported crudes.

Question No. **18**

Shell No. **EC 17**

Issue **Cumulative Effects Assessment**

Request

There is concern that the airshed, as defined by the RSA curve, will not be large enough once other projects are developed. The boundary may become unsuitable as more projects are implemented, particularly if they are close to the edge of the area. Relocation of the boundary should be considered in order to maintain appropriate background stations. At present 40% of the RSA will exceed the interim Alberta critical load of 0.25 keq/ha/a. Consideration should be given to modifying the RSA boundaries for future CEA.

Response

Shell agrees that the boundaries of the Regional Study Area will need to be expanded as more projects are added to the region, particularly if they are located close to the existing boundary. As each development proponent prepares its EIA, the boundary of the RSA will need to be expanded to include the resources that will be affected by that facility's air emissions.

Question No. 19

Shell No. EC 18

Issue **Cumulative Effects Assessment**

Request

There would be significant improvements to local and regional air related issues, including smog, acidifying emissions and climate change, if mitigation of NO_x emissions from fleets and facilities is addressed. There is sufficient evidence in the EIA, CEA and RDR to warrant further review of NO_x reduction opportunities.

Response

Shell is exploring opportunities to reduce emissions from fleet and facilities (e.g., minimizing fuel consumption, reducing haul distances, constructing and maintaining good roads, and optimizing the use of equipment through an appropriate fleet dispatch system). Engine emissions will be an integral part of evaluation when purchasing new equipment. Good engineering practices will be employed in the design of facilities (e.g., commitment by Shell to install low-NO_x burners on fixed plant equipment).

Question No. 20

Shell No. EC 19

Issue **Cumulative Effects Assessment**

Request

Model results show that ozone levels will exceed the 82 ppb guideline in some locations. Additionally, nitrogen deposition in the region is of concern, and loadings will continue to increase as more projects are developed. The burning of fossil fuel is increasing CO_2 emissions from the region. Environment Canada recommends that while ongoing modeling will be necessary, efforts must also focus on developing mitigation options.

Response

One of the purposes for modeling, and for monitoring data collection, is to identify environmental issues of concern, then, where appropriate, develop mitigation to manage environmental effects. Monitoring to validate the modeling predictions is a critical step in managing environmental effects. If monitoring verifies the fact that the environment is being affected, mitigation options will be implemented. Now ozone modeling results are presented in Section 7.3, (Ozone Formation) in the Project Update.

Question No.	**21**
Shell No.	**EC 20**
Issue	**Cumulative Effects Assessment**
Request	Environment Canada strongly encourages active participation in the Southern Wood Buffalo Airshed Zone activities to monitor, manage and address air quality issues in the region.
Response	Shell has been participating as an observer in the Wood Buffalo Environmental Association (WBEA) and, with the start-up of the Muskeg River Mine Project pilot plant, can now apply for membership to the WBEA. The tasks being performed under these cooperative efforts include developing and implementing monitoring programs, the data from which can be used to address air quality issues.

Question No.	**22**
Shell No.	**EC 21**
Issue	**Wildlife and Habitat**
Request	The proponent indicates that riparian wetlands will be lost in areas adjacent to the Muskeg River as a result of clearing. Reference is made to a 100 m riparian buffer zone, but buffer zones adjacent to the Muskeg river (Figure E11-12) appear in many places to be much less than this, particularly along Cell 1 and the adjacent reclamation material storage (RMS), and by the plant site. A 1 km buffer zone should be used throughout the study site to ensure the integrity of the riparian habitat, and to reduce disturbance to wildlife using that habitat (refer to comments in Barriers to Movement).
Response	A minimum 100 m buffer zone on either side of the Muskeg River will be respected as per the AEP Integrated Resource Management Team.

Question No.	**23**
Shell No.	**EC 22**
Issue	**Wildlife and Habitat**
Request	The proponent has indicated that the residual impacts of change in wildlife habitat for Cape May Warbler is moderate (2-30 years). However, it is also noted that development of suitable

white spruce dominated forest, the critical habitat for Cape May Warbler, will take over 100 years. The duration of impacts on the Cape May Warbler, therefore, will be long-term, not moderate (E11-62, Table E11-8).

Response

The impact duration is long-term. Table 11-8 was in error and has now been corrected. The revised table, together with other corrected tables for EIA Volume 3, Part 1, Section 11, is included in Attachment 5 at the end of the AEP responses.

Question No. 24

Shell No. EC 23

Issue **Wildlife and Habitat**

Request

The proponent indicates that some roads on the site will remain to provide access to wildlife resources (Vol. 3, p. E11-17). This is identified as a positive residual impact because of the increased access for recreation, hunting, forestry and trapping (Vol. 1, p.A-36 and 37). While increased access is positive for these activities, it is negative for wildlife. The proponent should evaluate the cumulative effects of a network of roads in the area, as they further fragment habitat and increase disturbances. Details on the location and extent of the proposed roads are required to fully assess potential impacts. The direct impact of ongoing access to the site on wildlife resources should also be discussed in the EIA.

Response

Decisions on future access will be made through consultation with regulators and stakeholders and will not be made for many years. Shell expects that all roads will be reclaimed. Therefore, residual cumulative effects should be negligible. However, AEP may direct Shell to leave some roads for future oil sands, recreational or other uses.

No hunting or trapping will be allowed on the lease during the construction and operation phases of the mine. Therefore, impacts related to increased access will not occur.

Question No. 25

Shell No. EC 24

Issue **Wildlife and Habitat**

Request

Environment Canada is concerned about the loss of wildlife biodiversity in the regional study area (RSA). Environment Canada acknowledges that the proponent's proposed reclamation program is to restore the natural biodiversity of the area to the largest extent possible. With complete forest removal, it will, however, require a minimum of 70-95 years (pine) and 100-140 years (spruce) for trees to grow 10 m in height to provide a suitable overstory canopy. This will affect canopy nesting birds, and species that use snags will be excluded from the area for at least 100 years. The proponent should endeavor to protect small enclaves of mature trees within buffer zones, wildlife corridors and riparian areas.

Response

The phased nature of the development and progressive reclamation of the mine will offset some of the impacts identified. Shell will also try to protect small enclaves of mature trees within buffer zones, wildlife corridors and riparian areas.

Question No. 26

Shell No. EC 25

Issue **Wildlife and Habitat**

Request

It is not readily apparent how the proposed mitigation measures listed will address changes in wildlife abundance or diversity (p.A-30, Vol.2). A complete list of mitigation measures designed to address the question of wildlife abundance and diversity should be provided.

Response

Through reclamation, Shell will replace as many of the pre-disturbance vegetation communities as possible in similar landscape patterns to those that existed before disturbance. However, because of the better drained nature of the reclaimed landscape, several lowland vegetation communities will not be re-established. This "coarse-filter approach" to wildlife habitat management, assumes that, by replacing habitat as similar to possible to that removed, similar wildlife species in similar levels of abundance will become established.

Mitigation measures to address wildlife abundance and diversity will include:

- locating the development away from important wildlife habitat (e.g., minimum of 100 m to the Muskeg River, 300 m to the Athabasca River escarpment, 800 m to Isadore's Lake)
- minimizing the footprint of the development (e.g., restricting dump size, use of common access and utility corridors)
- pursuing progressive reclamation of the development area to equivalent pre-development habitat capability
- timing site clearing to avoid most wildlife breeding or nesting periods (most clearing will occur during the winter)
- using no-disturbance buffer zones around known raptor nest sites, where feasible, to minimize impacts of site clearing
- establishing wildlife corridors within the LSA
- planning common access and utility corridors to minimize the number of crossings of wildlife corridors
- constructing crossings at right angles to wildlife corridors, wherever possible
- using berms, residual and planted vegetation and buildings to reduce the transmission of noise to adjacent habitats

- timing activities if possible, to avoid critical seasons for wildlife (see EIA Volume 3, Part 1, Section E11.6.1)
- prohibiting activities within 250 m of active raptor nests (Westworth 1996, Environment Canada 1997), if feasible
- prohibiting personnel from carrying firearms or hunting on the LSA
- prohibiting the use of private vehicles and ATVs within the LSA
- prohibiting hunting and trapping on the LSA
- prohibiting access by the public to the LSA
- using beaver deterrent devices on culverts
- monitoring and removing beaver dams at culverts regularly
- incinerating or storing all food wastes in bear-proof containers and transporting them off-site
- instructing and educating project workers not to feed wildlife
- implementing a nuisance wildlife management plan, in cooperation with Fish and Wildlife Service and AEP
- designing straight roads with long lines-of-sight, where feasible
- mowing rights-of-way regularly to increase visibility
- implementing signage and reduced speed limits (60 km/h) at key wildlife crossing areas
- using buses to transport staff
- using camps on-site to reduce traffic volumes
- keeping snow berms along roads during winter to a minimum height
- prohibiting the use of salt (NaCl) on roadways during winter
- using an oil recovery system (e.g., booms, skimming devices) on the tailings settling pond
- using bird deterrent devices, such as human effigies and propane-fueled cannons, particularly during the spring and fall migration periods
- maintaining a vegetation-free shoreline in the tailings settling pond
- participating in the Oil Sands Bird Protection Committee to discuss mitigation results and strategies
- using markers, such as:

    - aviation spheres, to mark transmission lines
    - PVC spirals, to mark ground wires
- insulating power line ground wires
- using perch guards on power line poles to deter birds from perching
- using raptor-safe construction standards (APLIC 1996)
- designing reclaimed landforms to include diversity and microtopographic relief
- designing all slopes to be less than 4:1
- designing reclaimed vegetation communities to provide key wildlife habitat variables for KIRs
- using native species in reclamation, wherever possible
- planning so that vegetation community patch size, shape and juxtaposition will approximate those of pre-disturbance conditions

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Question No. **27**

Shell No. **EC 26**

Issue **Wildlife and Habitat**

Request A discussion of the impacts of the project on the biodiversity of vegetation has been provided (E-7) , but it does not include a discussion of the impacts of the project on the overall biodiversity. This linkage and discussion should be provided.

Response Biodiversity was measured at a variety of scales and levels, as shown in Table 26.

Table 26: Biodiversity Indices (in response to EC 26)

Scale	Level	Indices	Measures of Assessment	Assessment
Landscape (ELC Section)	Composition	Richness • number of macroterrain units	decrease = loss in biodiversity	The number of macroterrain units will not decrease as a result of the Muskeg River Mine Project.
	Structure	Patch size (macroterrain) • mean • range (min-max)	increase/decrease = change in biodiversity decrease = loss of biodiversity	The mean patch size of macroterrain units will decrease from 685 ha to 413 (Table E7-4). The range in patch size will decrease from 15-2,481 ha to 13-1,1434 ha (Table E7-4)
Community (ELC Section)	Composition	Richness • number of types of ELC units in each macroterrain) Richness • number of polygons in each macroterrain	decrease = loss of biodiversity decrease = loss of biodiversity	The ELC richness (number of ecosite bases/soil type) within each macroterrain unit will decrease from 446 to 396 types (Table E7-5) The number of ELC polygons or patches within each macroterrain will decrease from 5144 to 2810 patches (Table E7-6). However, it is expected that with successive reclamation, enhanced landform designed the ELC patches will increase over time.
	Structure	Patch size (ELC) • mean • range (min-max)	increase/decrease = change in biodiversity decrease = loss of biodiversity	Overall, the mean patch size will increase from 2.13 ha to 2.37 ha (Table E7-7). The overall range in ELC patches however will not change (<0.1 -292.0 ha) (Table E7-7). The large patches and small patches will generally remain unaffected by development.

Question No. 28

Shell No. EC 27

Issue **Wildlife and Habitat**

Request Changes in the biodiversity of the LSA and RSA should be monitored during the construction, operation, and closure phases of the Muskeg Mine. The EIA should include an explanation of how exactly overall biodiversity will be measured and monitored.

Response Shell will follow the recommendations detailed in the *Guidelines for Reclamation to Forest Vegetation* (1998) prepared by the Oil Sands Vegetation Reclamation Committee to monitor changes in biodiversity in the LSA. Currently, there are no programs designed to measure changes in biodiversity in the RSA. Shell will raise this concern with the Athabasca Oil Sands Cumulative Effects Assessment Working Group.

Question No. 29

Shell No. EC 28

Issue **Wildlife and Habitat**

Request It is not clear in the EIA as to what the actual minimum width of the corridors will be. The proponent has stated that a 1km corridor is recommended for moose, but suggests that this width could be reduced to 350 m or less in places. No evidence is provided to support this proposal. Corridor widths proposed for one species are not necessarily appropriate for others. A minimum width of 1 km should be maintained to ensure that all species are accommodated.

Response The conceptual corridor design is provided in EIA Volume 3, Part 1, Figure E11-12. Corridors will be a minimum of 1 km in width, except between Cell 1 and the RMS. At this point, the corridor might be reduced in width to 350 m.

Within the Bow Valley Corridor, the Three Sisters EIA (UMA 1991) recommended a minimum width of 350 m for primary corridors and 187 m for secondary corridors, based on elk requirements for secure habitat and hiding cover, respectively (Thomas 1979). Following review of the EIA, the NRCB (1992) recommended that corridors be a minimum of 350 m wide, except in unusual circumstances.

Question No.	30
Shell No.	EC 29
Issue	**Wildlife and Habitat**
Request	A monitoring program should be initiated to determine wildlife use of the corridors.
Response	Shell is working with Fort McKay to investigate and confirm corridor use by wildlife.

Question No.	31
Shell No.	EC 30
Issue	**Wildlife and Habitat**
Request	Activities around riparian areas, and other critical wildlife areas on the LSA, should be timed to avoid critical breeding, nesting and fledging periods for migratory birds and other wildlife. For migratory birds, activities should be restricted between April 15 and July 30.
Response	Where feasible, activities adjacent to riparian areas will be timed to avoid critical seasons for wildlife (see EIA Volume 3, Part 1, Section E11.6.1).

Question No.	32
Shell No.	EC 31
Issue	**Wildlife and Habitat**
Request	"The first stage of clearing, drainage and grading work for plant site and haul roads will be completed by September, 1999" (p.4-37,Vol.1). Clearing and site preparation should be completed outside of the breeding and nesting season between April 15 and July 30. Details of the development schedule are required in order to fully assess the potential impacts on wildlife.
Response	Where feasible, the first stage of clearing, drainage and grading work for the plant site and haul roads will be completed during winter 1998-1999 while the ground is frozen. This work will be completed before the April 15 and July 30 timeframe for breeding and nesting.

Question No.	**33**
Shell No.	**EC 32**
Issue	**Wildlife and Habitat**

Request Development should be staggered to provide a continuous supply of young deciduous vegetation to minimize the impact on bird populations attracted to the deciduous forests.

Response Development will be phased to ensure that most seral stages are available to wildlife within the LSA at any time. For a list of mitigation measures around wildlife, see the response to EC 25.

Question No.	**34**
Shell No.	**EC 33**
Issue	**Non-Game Breeding Birds**

Request The abundance and diversity of breeding and migrating terrestrial non-game birds within the proponents Local Study Area (LSA) is equal to that found in other regions of the boreal forest (Francis and Lumbis, 1979; McLaren and Smith, 1985;, Westworth et. al. 1996; Golder 1997g). Moreover, within this biome, it has been demonstrated that distinct bird communities are associated with various seral stages of forest growth. In assessing the impacts of development on breeding and migrating non-game birds, it is important to consider the various habitats that offer sufficient suitability to sustain breeding populations.

Environment Canada has a number of concerns related to the use of non-representative indicator species, the selection and appropriateness of some species chosen and the assessment of habitat to evaluate the environmental impacts.

The methods used for the breeding bird surveys are reasonable, including the analytical approach of using TWINSPAN and the Kruskal Wallace tests. However, the TWINSPAN output is not explained sufficiently. This analysis should include how species and site segregations occurred according to cut level and which groups were delineated by the first, second, third, and fourth divisions.

Response The hierarchical breakdown of cut levels (i.e., group classification) is represented by the thickness of lines delineating community types and bird species guilds in Table 5.9 of the *Wildlife Baseline Conditions Report*. Thus, ecotypes were first classified into lowland bog and fen communities (A and B), and upland communities containing trembling aspen and white spruce (C). This classification was based on the relative abundance of bird species in groups 1 to 3 compared to groups 4 and 5. For example, the relative abundances of species in groups 2 and 3 was greater in community Types A and B than in community Type C. In contrast, species in group 4 were more strongly associated with upland trembling aspen and white spruce stands than lowland fen and bog complexes.

TWINSPAN then distinguished two community types within the lowland ecotypes to give community Types A and B. This classification was the result of differences in the relative abundance of bird species in groups 1 and 2 compared to groups 3 to 5 between the two community types. Although the relative abundance of species in groups 1 and 2 were similar for community Types A and B, species in groups 3 and 4 were relatively more abundant in community Type B than community Type A.

The third cut level distinguished group 1 from group 2, and group 5 from groups 3 and 4. Although the relationship is not strong, which is a consequence of cut level, the results do suggest that species in groups 1 and 5 are more general with respect to their habitat associations than species in groups 2, 3, and 4.

Question No. 35

Shell No. EC 34

Issue **Non-Game Breeding Birds**

Request The results of the TWINSPAN should be discussed in the context of the proposed development and expected impacts, including potential impacts upon the different community types.

Response An analysis of the breeding bird community types is in Table 34-1 and summarized in Table 34-2. Type D was defined to include those ecosite phases not included in the TWINSPAN analysis (open water and disturbed types).

Community Types A and B will be most negatively impacted by the development post-closure (-40% and -28%, respectively), as these lowland types will be lost at the expense of upland types.

Question No. 36

Shell No. EC 35

Issue **Non-Game Breeding Birds**

Request For the migratory birds, all of the indicator species that were selected occur in such low numbers that the detection of any statistically meaningful change in populations through time is unlikely. This limits their use as a monitoring and assessment tool. At a minimum , a power analysis of the magnitude of detectable change, given the available data, should be conducted to confirm the magnitude and probability of detection of changes.

Response Shell will design its wildlife monitoring programs in detail once it receives project approval. Shell will be discussing a wildlife monitoring program with Environment Canada. If breeding birds are included as one of the monitoring programs, the abundance of all bird species, not just KIRs included in the EIA, will be monitored.

Table 34-1: Analysis of Breeding Bird Types

Vegetation Type		Bird	Baseline	Impact Area		Reclaimed	Closure
Map Code	Ecosite Phases	Commun.	Area	impact	remain	Area	Area
a1	Lichen Pj	C	106	49	57		57
a1/g1 complex	Pj-Lt	C	21	4	17		17
b1	Blueberry Pj-Aw	C	878	335	543	218	761
b2	Blueberry Aw(Bw)	C	0		0	102	102
b3	Blueberry Aw-Sw	C	67	11	56	72	128
b4	Blueberry Sw-Pj	C	286	98	188	596	784
c1	Labrador Tea-mesic Pj-Sb	A	20	3	17		17
d1	Low Bush Cranberry Aw	C	1,525	359	1,166	96	1,262
d2	Low Bush Cranberry Aw-Sw	B	169	38	131	729	860
d3	Low Bush Cranberry Sw	C	15	0.1	14.9		14.9
e1	Dogwood Pb-Aw	C	61	9	52		52
e1/f1	Pb-Aw	C	66	0.1	65.9		65.9
e2	Dogwood Pb-Sw	C	4	0	4		4
e2/f2	Pb-Sw	C	9	2	7		7
e3	Dogwood Sw	C	93	0	93	1,550	1,643
g1	Labrador Tea-subhygric Sb-Pj	A	8	6	2		2
h1	Labrador Tea/Horsetail Sw-Sb	A	123	53	70		70
shrub	Shrubland	C	119	12	107		107
Sb/Lt	Sb/Lt Complexes	A	61	30	31		31
AIH, AIG, AIM	Cultural Disturbance	D	471	232	239		239
NMC	Cutbanks	D	12	0	12		12
i2	Shrubby Bog	A	20	0	20		20
j1	Treed Poor Fen	B	356	168	188		188
j1/g1 complex	Lt/Sb-Pj	B	27	0	27		27
j1/h1 complex	Sb/Sw-Lt	B	74	0	74		74
j2	Shrubby Poor Fen	B	1,182	532	650		650
j2/h1 complex	Sw/Sb-Fen Complex	B	2	0	2		2
k1	Treed Rich Fen	B	1,370	739	631		631
k2	Shrubby Rich Fen	B	2,136	1,084	1,052	17	1,069
k3	Graminoid Rich Fen	B	51	6	45		45
l1	Marsh	B	85	4	81	119	200
STNN, SFNN, SONS	Swamp (coniferous, deciduous and shrub)	B	1,359	531	828	308	1,136
WONN	Shallow Open Water	D	57	6	51		51
NWL	Lakes and Ponds	D	114	32	82	536	618
NWR	Rivers	D	7	0	7		7
Mine	Mine Footprint	D			4,343		
	Total		10,954	4,343.2	10,954	4,343	10,953.8

Table 34-2: Summary of Breeding Bird Communities

Community	Baseline (ha)	Impact (ha)	% Impact	Closure (ha)	% Change At Closure
A	232	92	-40	140	-40
B	6,811	3,102	-46	4,882	-28
C	3,250	879	-27	5,005	54
D	661	270	-41	927	40
Total	10,954	4,343	-40	10,954	0

Question No. **37**

Shell No. **EC 36**

Issue **Key Indicator Resources**

Request

The Key Indicator Resources species chosen for this project was based on a previous selection process used for other developments. KIRs were selected based on a scoring of species political importance (endangered status), commercial and subsistence economic importance, non-consumptive importance and ecological importance (Vol. 2, D11-3), however, no details on the exact selection process have been provided in this EIA. Comments on the appropriateness of the selected KIRs follow.

KIRs should be selected so that the species chosen is a good representative of a specific type of habitat and its presence/absence over the life of a project can be monitored to continually evaluate impacts. Habitat Suitability Indices (HSII) models are then developed for KIRs to predict the suitability of habitat for that particular species. If a species is chosen that is usually present on the study site in very low in numbers and is rarely seen, it is not very likely that they will provide any useful data in terms of monitoring and assessing change.

The selection of migratory bird KIRs based on endangered status is not very useful and other species should be considered. Similarly, the Western Tanager, Pileated Woodpecker and Great Gray Owl should also be reconsidered as KIRs because they occur in such low numbers on the study site.

Response

The KIRs selected for the two other developments were approved by stakeholders and regulators for those projects. One of the developments was the Aurora Mine Project which lies directly north and east of the Muskeg River Mine Project.

However, regulators involved in reviewing the plans for the Muskeg River Mine Project EIA were given the opportunity to review the list and make recommendations. The western tanager and pileated woodpecker were added to the KIR list by regulators as a result of this process.

See also the response to EC 35.

Question No.	**38**
Shell No.	**EC 37**
Issue	**Key Indicator Resources**

Request The Cape May Warbler was chosen as a KIR partially because it is representative of terrestrial non-game birds in a white spruce forest habitat in the LSA. The Western Tanager was chosen because it is a representative of open forest mixed wood. The habitat suitability models for these species were created using data from other study areas. The models should be verified in the regional and local study area.

Response As noted by the reviewer, the use of low density breeding bird species as monitoring indicators is questionable. Therefore, the value of ground-truthing the habitat models for these two species is questionable.

Question No.	**39**
Shell No.	**EC 38**
Issue	**Key Indicator Resources**

Request The Cape May Warbler has been included in Community Type B (late successional wetlands) because of the bird-vegetation community associations (Vol. 2, D11-15), based on the TWINSPAN test results (deficiencies noted above). Mixed trembling aspen-white spruce was placed into this community type. The Cape May Warbler is not a good choice for an indicator for this association because it is not a riparian habitat species. Its occurrence in these buffers relates strictly to the occurrence of mature white spruce. In addition, this species is known to fluctuate significantly in population due to the relative abundance of spruce budworm. As such, it makes a poor indicator species of purely habitat change characteristics. The Cape May should not be used to monitor and assess changes in habitat and in particular wetland habitats.

Response See the response to EC 35.

Question No.	**40**
Shell No.	**EC 39**
Issue	**Key Indicator Resources**

Request The Palm Warbler is highly associated with muskeg, is a neotropical migrant, is relatively more common than some other species and is a species of concern due to its relatively narrow wintering distribution. The loss of muskeg habitat due to the project will clearly influence this species on the LSA. For the monitoring of wetland changes, given the large impacts on the muskeg habitat, the Palm Warbler should be selected as a species to monitor.

Response See the response to EC 35.

Question No. 41

Shell No. EC 40

Issue **Key Indicator Resources**

Request The use of Key Indicator Species has been widely used because management for many species may be simplified and made more cost-effective by considering only a small group of indicator species (Niemi et. al. 1997; Landres et. al. 1988). The assumption, however, in the use of indicator species is that habitat quality maintained for the KIR will also be suitable for other species. Using indicators to assess population trends and habitat suitability for other species is usually inappropriate without confirmatory research, which has not been done for this project. The monitoring of rare or individual species in the forest presents a number of problems, including lack of representation of other species, and low population levels which are difficult to monitor. Although the habitat types for Cape May Warbler and Western Tanager are known to support diverse and abundant bird communities, the analysis does not assess the impacts that development will have on birds that occupy other habitat classes.

Response The KIRs used for the EIA were considered to represent most of the main habitat types within the study areas (e.g., lowland, upland, riparian). It was considered reasonable to assume that it would be sufficient to cover all of these main types over a broad range of taxa (e.g., mammals, birds, reptiles and amphibians), and not to cover all types within each taxa.

Question No. 42

Shell No. EC 41

Issue **Key Indicator Resources)**

Request The approach of relying on a few KIR species to monitor and assess the impacts of the project on migratory bird habitat should be avoided. Breeding bird surveys involve the recording of all species using point counts. Extra effort would not be required to obtain this data on one species as opposed to all species.

Response See the response to EC 35.

Question No.	**43**
Shell No.	**EC 42**
Issue	**Key Indicator Resources**

Request

Habitat suitability models should be developed for many other terrestrial non-game bird species that occupy vegetation classes other than the types represented by the KIRS selected. Species that are associated highly with a specific habitat type, and species that are abundant enough to monitor and assess changes in its habitat type, should be selected. Further analysis could identify possible enclaves of critical habitat that could be maintained or protected from development within the LSA. Even tiny enclaves of important habitat such as mature conifers could expedite early re-colonization of reclaimed habitat by several bird species

Response

See the response to EC 40.

Question No.	**44**
Shell No.	**EC 43**
Issue	**Waterfowl, Colonial Waterbirds, and Shorebird – Tailings Ponds**

Request

Kearl Lake is locally important to staging duck populations and the Peace-Athabasca Delta is nationally important to a variety of migratory bird populations (Posten et al, 1990). Migratory birds may use the Muskeg tailings pond en-route to such important staging areas. The tailings pond contains un-recovered bitumen which may form floating mats on the surface, sink to the bottom, or become dispersed throughout the ponds. The consolidated tailings (CT) process should minimize bitumen release, reduce the life of the tailings ponds, and thereby reduce effects on birds associated with the tailing pond. The tailings and CT ponds should be closely monitored to determine the use by avifauna, mortality, phenology, and chronology of bird species affected.

Response

Wildlife deterrent systems similar to those designed for the tailings ponds for the two existing oil sand facilities will be implemented for the Muskeg River Mine Project. In addition, the shorelines of the tailings settling pond will be left unvegetated, reducing its attractiveness as wildlife habitat. These measures have proven successful at reducing use of the ponds by wildlife. Shell will monitor the use of the tailings settling pond by wildlife.

Question No. 45

Shell No. EC 44

Issue **Waterfowl, Colonial Waterbirds, and Shorebird – Tailings Ponds**

Request

To minimize the potential use of the tailings and CT ponds by migratory birds, the following measures should be implemented.

- Gradual filling of tailings ponds should be minimized to avoid the artificial creation of shoreline habitat and shallow edges suitable to shorebirds and waterfowl. Should the present bird deterrent procedures become ineffective, restraining booms and skimming devices should be activated to minimize floating bitumen material. In addition, a contingency plan should be prepared to address waterfowl and shorebird concerns, such as rehabilitation of oiled birds, in the event of dyke failure or oil spillage.
- Recognizing the need to ensure the engineering stability of dykes, the banks of the tailings pond should be constructed as steeply as possible to eliminate gradual shorelines; if the dykes are to be vegetated then the use of tall fast-growing treed vegetation (i.e. poplar, willow) is strongly recommended; and emergent vegetation from the water surface should be eliminated.
- A comprehensive deterrent program is required for the tailings and CT ponds during the peak spring and fall migrations. The proponent is encouraged to investigate and use the best available technology for deterring devices.

Response

Shell will take these recommendations into consideration. See also the response to EC 43.

Question No. 46

Shell No. EC 45

Issue **Waterfowl, Colonial Waterbirds, and Shorebird – Tailings Ponds**

Request

The Oil Sands Bird Protection Committee, with government and private sector representation, was created to determine and coordinate research needs and activities related to hazards to birds affected by oil sands development. Information regarding inadvertent deaths of migratory birds at tailings ponds is discussed at annual meetings. This committee should be reactivated and consulted in considering bird deterrent programs for the Muskeg River project.

Response

Shell would be a willing participant if the committee was reactivated.

Question No. 47

Shell No. EC 46

Issue **Waterfowl Surveys**

Request

Environment Canada has significant concerns with the survey methods and with the conclusions drawn from the surveys.

Waterfowl investigations consisted of two aerial surveys and one ground survey. Aerial surveys were conducted in the spring (May 17, 1997) and late summer (August 28m, 1997), using a Jet Ranger helicopter at speeds from 130-160 km/h, approximately 100 m above ground level, but lower when conditions allowed. (Golder 1997g).

The August survey was conducted about one month too late to obtain any meaningful observations on brood surveys.

The spring survey was appropriately timed, but both the spring survey and the August survey were flown at speeds that were too fast and at an altitude that was too high to obtain meaningful results. By comparison, U.S. Fish and Wildlife Surveys flown at 30-50 m above ground level, with a speed of 145-165 km/h in fixed-wing aircraft, identify less than 50% of ducks present.

At the height and speed of the survey the proponent conducted, the observers would likely see about 10% of birds that were present. At a height of 100 m, it is very difficult, if not impossible, to identify actual species, yet Table 5-6 of Golder (1998g) indicates no unidentified species. Environment Canada considers this extremely unusual. Surveys for waterfowl should be repeated in an acceptable manner to collect meaningful results. If necessary, Environment Canada will be available to consult on survey methods.

Response

The number, size and habitat quality of ponds that will be impacted by site clearing does not warrant a repeat of the spring surveys. The results of the HSI modeling exercise also suggest that duck habitat suitability is low within the LSA. The dabbling duck model indicated that only 4% of the LSA is high quality habitat (see report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*).

Question No. 48

Shell No. EC 47

Issue **Waterfowl Surveys**

Request

Visibility Correction Factors have not been applied to survey data. During aerial surveys of breeding waterfowl, not all birds present are sighted and in order to improve the accuracy of the survey, it is necessary to correct the data obtained by applying visibility correction factors (VCFs). Correction factors or "visibility ratios", are computed by comparing ground counts (assumed to be accurate) and fixed wing counts. The U.S Fish and Wildlife Service (U.S. F&WS) and the Canadian Wildlife Service have developed correction factors for visibility biases in aerial surveys of boreal forest ducks, which also takes into account the use of helicopters (Hines et al. 1989). These VCFs were developed by comparing fixed-wing and helicopter counts and are the accepted VCFs for all U.S. F&WS surveys done in Western Canada.. Hines et al (1989) found that VCFs are not needed if the helicopter is flying at low altitude and slow speeds as helicopter and ground counts were not significantly different. However, at the speed and height of the survey conducted for the Muskeg project, they would not have made the results more meaningful. Visibility Correction Factors should be applied to survey results to obtain more accurate estimates of populations.

Response See the response to EC 46.

Question No. **49**

Shell No. **EC 48**

Issue **Waterfowl Surveys**

Request The proponent found a two to three fold increase in number of observed birds during the aerial survey when compared with ground surveys. This was attributed to either the aerial survey being more effective than the ground survey (which is not likely, given the height and speed) or to many of the birds from the first survey migrating through to other locations. This latter explanation is not supported by any results. By the end of May, mallards for example, may have already finished breeding and the males will have departed for a molting marsh.

From the results of the August aerial survey the proponent indicated that the number of broods in the area was low and on this basis, suggested that nesting success in the area is poor or that many of the species observed in the spring surveys do not nest in the LSA. Environment Canada considers neither conclusion to be supported by any data. Past surveys at similar latitudes have indicated that mallards, for example, would have broods in the area by May 31 and they would be fledged and flying by the end of July. At the time of the survey at the end of August, broods could be anywhere. As stated, given the survey time, the height and speed, Environment Canada feels that less than 10% of the broods were accounted for in the survey.

The proponent indicates that migration of birds through the LSA may be an indication that the nesting habitat is limited or insufficient to meet the requirements of many species. Most species have, in fact, finished migrating by May 20 at the latest. The data provided do not support the conclusion that most birds were migrating through the area. Environment Canada recommends that the proponent re-evaluate their predicted impacts on waterfowl and adjust mitigation measures accordingly.

Response Shell agrees that the statements on mitigation are questionable. However, the quality of the habitat of the two small ponds for waterfowl is low. Therefore, impact reassessment is not warranted.

Question No. 50

Shell No. EC 49

Issue **Raptors – Hawks, Eagles and Falcons**

Request

Only one unoccupied raptor nest was located during an aerial survey done concurrently for waterfowl. Red-tailed Hawks were the only species identified during the survey. Bald Eagle and Osprey nests are located easily from aerial surveys, however, ground surveys are needed to locate accipiter nests. Nests occupied by other accipiters (Goshawks, Cooper's Hawk, Northern Harrier and Sharp-shinned Hawk, for example), need to be identified through detailed ground surveys.

Response

Surveys for accipiter nests will be conducted in sensitive areas (e.g., riparian, wildlife corridor and buffer areas) before any construction activity in these areas.

Question No. 51

Shell No. EC 50

Issue **Raptors – Hawks, Eagles and Falcons**

Request

If occupied Bald Eagle or Osprey nests are found during ground surveys, this should be documented. Where nests are found in riparian areas, buffer zones and wildlife corridors a vegetation buffer (minimum 50 m wide) should be provided to give a visible barrier to nesting raptors and to protect hunting raptors and their hunting perches. During the nesting and breeding season, a 250 m buffer around Bald Eagle and Osprey nests is recommended. Disturbance from vehicular traffic should be minimized in the proximity of any nests.

Response

The mitigation outlined will be considered if raptor nests are found in riparian areas, buffer zones or wildlife corridors.

Question No. 52

Shell No. EC 51

Issue **Raptors – Hawks, Eagles and Falcons**

Request

While no occupied Bald Eagle or Osprey nests were found during the aerial survey, incidental observations of adults and young were recorded. Trees and snags provide potential nesting and perching sites. Some tall trees and dead snags should be protected within 400 m of rivers, creeks, and lake edges within the LSA to mitigate impacts on Bald Eagles or Ospreys.

Response Shell will endeavor to leave tall trees and snags within riparian areas, buffer zones and wildlife corridors, wherever possible.

Question No. 53

Shell No. EC 52

Issue **Raptors – Hawks, Eagles and Falcons**

Request Muskeg provides good habitat for some species of raptors. As an example, Francis and Lumbis (1979) found that March Hawks (Northern Harriers) were widely distributed over the area. The EIA should include a discussion of the implications of the loss of this habitat to raptors.

Response Loss of wetlands vegetation communities, such as breeding bird communities A and B (see Table 34-1), within the LSA can be expected to have an impact (i.e., habitat loss of greater than 20%) on the species that depend upon these communities, including raptors, such as the northern harrier (marsh hawk).

However, species that are adapted to upland communities can be expected to benefit from the project in the long term.

Question No. 54

Shell No. EC 53

Issue **Peregrine Falcon**

Request Peregrine Falcons, an endangered COSEWIC species, commonly migrate along the Athabasca River corridor (Francis and Lumbus, 1979). Existing wetlands are important nesting areas and tree stands adjacent to wetlands provide prey species habitat for many raptors including Peregrine Falcons. As populations are now beginning to recover, the bird deterrent and oil rehabilitation programs should consider the potential increase in Peregrine Falcons during the spring and fall migrations, especially if potential prey (shorebirds) are likely to be present.

Response Shell will monitor raptor use of, and mortality caused by, the tailings settling ponds. Should peregrine falcons be found to frequent the ponds, further mitigation in the form of falcon or shorebird deterrence could be employed.

Question No. 55

Shell No. EC 54

Issue Owls

Request Owl surveys were conducted under poor weather conditions. The surveys should be repeated under better weather conditions. Short-eared Owl are usually more numerous later in April, if prey is available. Surveys conducted later in April may have resulted in more owls.

Response As stated by Environment Canada in EC 36, surveys of species that occur in low densities are not particularly useful. The owl surveys conducted for the EIA demonstrated that, despite the less than ideal conditions, owl densities are relatively low.

Question No. 56

Shell No. EC 55

Issue Owls

Request The Great Gray Owl was identified as an indicator species in the EIA. It requires trees with stick nests built by hawks. Because Great Gray Owls are dependent upon available rodent prey, their distribution is Holarctic across North America. Efforts should be made to protect trees older that 50 years and prey species habitats (graminoid fens) within riparian zones, buffer zones and wildlife corridors. Owls will not return to the area until very late in the reclamation stages of the project unless small enclaves of mature nesting habitat with sticknests are protected.

Response Shell will endeavor to protect trees older than 50 years and great gray owl prey species habitats (graminoid fens) within riparian zones, buffer zones and wildlife corridors.

Question No. 57

Shell No. EC 56

Issue Owls

Request The habitat suitability model for the Great Gray Owl was created using data from other study areas. Clarification is required on how the model was verified for the regional and local study area.

Response Shell will raise this issue with the Athabasca Oil Sands Cumulative Effects Assessment Working Group.

Question No. 58

Shell No. EC 57

Issue **Owls**

Request

The Short-eared Owl is listed as a vulnerable species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and incidental observations of this species were documented in the LSA. The Short-eared Owl has different habitat requirements than the Great Gray Owl. Consequently a habitat suitability index developed for the Great Gray Owl should not be extrapolated to the Short-eared Owl. This is a ground nesting owl which tends to be found in marshes, lakes, and muskegs nesting in well hidden depressions. The EIA should include a discussion of the impact of development on the habitat of the Short-eared Owl.

Response

The short-eared owl has a cosmopolitan range, but is largely absent from the Boreal Forest Region and areas of dense forest (Cadman and Page 1990). Therefore, its distribution within the LSA is likely to be limited to the non-forested areas. The fact that the short-eared owl is on the fringe of its breeding range within the LSA, that it has an irruptive population and that it is often nomadic makes it a poor candidate for a KIR for the EIA. The project will likely have a major impact on the habitat of this species, and also that of the northern harrier, a species with similar habitat requirements (see the response to EC 52).

Question No. 59

Shell No. EC 58

Issue **Other Species – Wolverine (vulnerable COSEWIC)**

Request

Environment Canada has concerns that continued disruption of travel corridors and fragmentation of habitat may impact endangered, rare or vulnerable carnivore populations. The distribution and abundance of the wolverine (vulnerable COSEWIC species) within the local and regional study areas has not been fully evaluated. The proponent had assumed that it is likely low since the density of wolverines is low for the Lease 88 and 89 area (Skinner and Westworth 1981) and no tracks were observed for the Aurora EIA (Westworth 1996). Estimated population density for the area was calculated by Westworth (1979) to be 0.08 animals/100km^2. Given these low densities, there is a concern that the cumulative development in the region will affect the ability of the wolverine to move through isolated population areas. Environment Canada recommends that the proponent make every effort to improve the baseline data set of wolverines in the area and define mitigation measures that would address these concerns.

Response

No wolverine tracks were recorded by Golder within the LSA for the Muskeg River Mine, or for Solv-Ex, OSLO, Syncrude's Aurora Mines, or for Suncor's Project Millennium. We do not recommend that baseline studies specific to wolverine be conducted.

Question No. 60

Shell No. EC 59

Issue **Whooping Crane (endangered COSEWIC)**

Request

The Whooping Crane is listed as an endangered COSEWIC species. These birds migrate to, and nest in, Wood Buffalo National Park to the north of the study area. Periodic sightings have been made of Whooping Cranes migrating through the area, and occasionally stopping over in the Oil Sands Area (Francis and Lumbis, 1979). Environment Canada recommends that the bird deterrent and oil rehabilitation programs continue with special emphasis on spring and fall migration periods.

Response

Shell agrees with this recommendation.

Question No. 61

Shell No. EC 60

Issue **Cumulative Effects – Wildlife and Habitat**

Request

Environment Canada notes that increasing development along the Athabasca River valley will cumulatively affect wildlife in the region by reducing and fragmenting habitat, and disrupting wildlife movement patterns. Although some impacts may be minimal within the Local Study Area (LSA), the development's contribution to impacts along the Athabasca River Valley within the entire Oil Sands Regional Study Area (RSA) need to be addressed.

Response

The only component of the Muskeg River Mine Project that will require new development in the Athabasca River valley is the pipeline and water intake facility associated with the fresh water supply system. The Athabasca River valley in this part of the region is protected through the requirements of the Integrated Resource Plan. The cumulative effects of habitat loss within the region were addressed in EIA Volume 4, Sections F11 and G11. Cumulative impacts to moose movement areas (linkage zones) were addressed in the report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project.* The cumulative effects on movement corridors is also recognized by the Athabasca Oil Sands Cumulative Effects Assessment Working Group.

Question No.	**62**
Shell No.	**EC 61**
Issue	**Cumulative Effects – Wildlife and Habitat**

Request

The cumulative effects assessment for the Muskeg Mine on wildlife focuses on calculating the incremental and total cumulative habitat loss due to vegetation clearing in combination with habitat loss due to other existing or proposed developments in the RSA. The success of this analysis is clearly dependent on the proper selection of Key Indicator Resource species (KIRs) and the proper development of habitat suitability models for each respective species. Concerns with the habitat suitability models and key indicator species were discussed earlier.

Response

Comment acknowledged.

Question No.	**63**
Shell No.	**EC 62**
Issue	**Cumulative Effects – Wildlife and Habitat**

Request

This cumulative effects assessment does not identify problems that may arise from the removal of small enclaves of critical habitat which support high biodiversity and abundance due to their location in the landscape relative to other habitat classes. For example, large coniferous trees on upland areas and near fens/bogs with good prey species abundance may be very important habitat for Bald Eagles. Important linkages between habitat and wildlife may be ignored if percent Habitat Unit (HU) calculations are only considered. The importance of habitat distribution needs to be addressed in the cumulative impact assessment.

Response

Spatial distribution of habitat was built into the HSI models of those species that were considered to require it (moose, dabbling ducks, great gray owl). Therefore, the cumulative effects analysis did take habitat distribution into account.

Small enclaves of habitat that might be important will be protected within the LSA of each project. For example, Shell's mitigation program will involve the protection of pockets of large trees, snags and other important wildlife features within riparian areas and local wildlife corridors. Such areas are difficult to map and cannot be considered for an assessment of cumulative effects for an area as large as the RSA.

Question No.	**64**
Shell No.	**EC 63**
Issue	**Cumulative Effects – Wildlife and Habitat**

Request

Important wildlife movement corridors are not discussed in the EIA. Some species may use very narrow corridors very frequently. Furthermore these high use corridors may represent a small percentage relative to the RSA. The cumulative effects of oil sands development on important wildlife corridors in the LSA should be addressed in the CEA.

Response

As assessment of moose linkage zones was given in the report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*, Section 6.2.14. The cumulative effects of development on movement corridors is recognized by the Athabasca Oil Sands Cumulative Effects Assessment Working Group.

Question No.	**65**
Shell No.	**EC 64**
Issue	**Cumulative Effects – Wildlife and Habitat**

Request

The cumulative long term impacts of water quality on wildlife populations in the region should also be addressed in the CEA.

Response

Cumulative long-term impacts of water quality on wildlife populations were evaluated in EIA Volume 4, Key Questions WCEA-2 and WRDR-2 in Sections F11.4.2 and G11.3.2. No impacts to wildlife health were predicted as a result of exposure to Athabasca or Muskeg River water during operation, at closure or in the far future.

Question No.	**66**
Shell No.	**EC 65**
Issue	**Cumulative Effects – Wildlife and Habitat**

Request

Reclamation plans will increase the lake area in the LSA. According to the current plans, the End Pit Lake will be adjacent to the Athabasca River. This could attract a significant number of waterfowl, shorebirds and consequently raptors to the area. The cumulative impact of such landscape changes on the avifauna in the region needs to be addressed.

Response

Shell agrees that the end-pit lake will provide additional habitat for waterfowl, shorebirds and raptors, and that the cumulative effects of these landscape changes should be addressed. Shell will raise this issue with the Athabasca Oil Sands Cumulative Effects Assessment Working Group.

Question No. 67

Shell No. EC 66

Issue **Cumulative Effects – Wildlife and Habitat**

Request

Some species of neotropical migrant songbirds are known to breed almost exclusively within the Canadian boreal forest. Other species have the most productive component of their range within these forests. It is generally accepted that Canadian forests constitute major "source" (prime breeding habitats) populations of several species of neotropical migrant songbirds compared with more fragmented forest patches south of this biome that may in fact be a "sink" (marginal, typically non-breeding habitats). It is currently unknown to what extent existing and proposed development and fragmentation of Canadian forests will affect the world's populations of numerous species of songbirds currently protected under the *Migratory Birds Convention Act*. Continent-wide consequences for these birds and other wildlife are possible given that the vast majority of this habitat is under development by forestry and mining operations. The proponent should identify future plans to evaluate its contribution to impacts from development of forestry habitat.

Response

Impacts of the Muskeg River Mine on breeding bird habitat are small relative to the impacts of forestry operations if one considers the area of disturbance alone. However, the disturbance is different in terms of its duration, with mine-related impacts being longer. The contribution of this effect on breeding birds will be evaluated during breeding bird surveys that will be conducted on reclaimed lands to monitor the success of the re-establishment of habitat for these species.

Question No. 68

Shell No. EC 67

Issue **Cumulative Effects – Wildlife and Habitat**

Request

The two primary end land uses for the reclaimed landscapes are commercial forest revegetation and moose habitat. Environment Canada has concerns about the removal of many diverse habitats and the replacement with fewer and more homogeneous landscape types. The proponent should clearly identify how these end land use objectives were derived and discuss the implications to biodiveristy (refer to comments on Wildlife and Habitat).

Response

The end land use presented in the EIA is a conceptual plan only. It is expected that future iterations of the plan will allow for the replacement of a greater diversity of vegetation communities. See also the response to AEP 35.

The impact of the conceptual reclamation plan on biodiversity was estimated in Section 6.1.13 in the report *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project.* Reclamation was expected to result in a net change over baseline conditions of +6% for mammals, -6% for birds and -17% for reptiles and amphibians.

Question No. **69**

Shell No. **EC 68**

Issue **Cumulative Effects – Wildlife and Habitat**

Request Drawdown of the Basal Aquifer will increase the downward seepage of water from Kearl Lake, and complete recovery of groundwater levels in the Basal Aquifer is likely to take up to 30 years after the mine closes. This downward seepage from Kearl Lake is expected to be 63mm/year, or 14% of the mean annual precipitation received by the lake, but the proponent does not state for how many years this annual loss will occur. Environment Canada has strong concerns about the loss of water from Kearl Lake as it relates to wildlife and habitat as it is a locally important lake for staging ducks (Posten et al., 1990) and is used extensively by other wildlife in the area.

Response See the response to DFO 37-45.

Question No. **70**

Shell No. **EC 69**

Issue **Cumulative Effects – Wildlife and Habitat**

Request The following should be explained in the CEA:

69.1 what is the maximum level of water drawdown of the lake expected to be?

Response 69.1 See the response to DFO 37-45.

Request 69.2 when is the maximum drawdown expected to occur and for how long?

Response 69.2 See the response to DFO 37-45. Maximum drawdown will depend in part on the depressurization activities of Aurora North and South and Mobil Kearl oil sands mines, in addition to the Muskeg River Mine. Shell expects maximum drawdown to be quasi-steady state, occurring after about five years and persisting for the life of mining, before beginning to recover. The overall recovery period will last up to 30 years after mining has finished.

Request 69.3 what is the expected water quality of the lake throughout this period?

Response 69.3 No effects on water quality are expected as a result of drawdown.

Request 69.4 what are the expected impacts on wildlife through this period expected to be?

Response 69.4 No effects on water quality, and hence wildlife, are expected.

Request 69.5 what are the proposed mitigation plans to respond to the predicted impacts?

Response 69.5 The conceptual groundwater monitoring program in the vicinity of Kearl Lake is provided in the response to DFO 45.

Question No. 75

Shell No. EC 70

Issue **Cumulative Effects – Wildlife and Habitat**

Request

The evaluation of biodiversity at the macroterrain level is not useful. It is a generalization of the landscape and it is possible to keep reclassifying the landscape upward until no significant changes are found. As an example, of the 10 macroterrain units (F7-5), it appears that the McClelland Lake Glaciofluvial Plain and Patterned Fen is, on a percentage basis, significantly affected. However, most of the impact is from forestry and to a much lesser extent, open pit mining. The Muskeg River project is affecting the Steepbank Organo-Lucustrine Plain only. The use of macro-terrain units as an indicator of biodiversity is not reflective of the changes.

Environment Canada does not agree that development in the RSA will not effect biodiversity or that the habitat is being reclaimed to equivalent or better habitat. The habitat will be different but better for some species, and worse for other species (refer to Wildlife and Habitat comments).

The proponent indicates that the project will affect 1 percent of the RSA. The purpose of the CEA is to determine the percentage of the RSA that is being affected by all developments. The proponent is encouraged to reduce, to the greatest extent possible, the loss of patterned fens and bogs on the RSA. Adequate buffer zones around riparian zones should be rigorously and consistently adhered to.

Response

Biodiversity must be considered at many levels, so the assessment was conducted at the landscape, community and species levels. Analysis of any one level cannot be considered in isolation. See the response to EC 27 for the results of the assessment.

The term "equivalent habitat capability" as used in the EIA is meant to relate to the net effect on habitat capability for all species combined. It is recognized that habitat for some species will be gained while habitat for others will be lost, relative to baseline conditions. The results of the HSI analysis predicts that, following reclamation, the habitat capability of the LSA will be higher than baseline conditions for 10 KIRs and lower than baseline conditions for two KIRs (see Table 97 in *Wildlife Habitat Suitability Indices (HSI) Modelling for the Muskeg River Mine Project*). These numbers are also given in EIA Volume 4, Table F11-1.

Buffer zones around riparian zones will be added, where possible.

Question No.	**76**
Shell No.	**EC 71**
Issue	**Monitoring and Research**

Request

In order to evaluate the accuracy of predicted impacts and proposed mitigation measures, it is important that a comprehensive monitoring program be implemented. This program should address information gaps with respect to project-specific and cumulative effects. A detailed monitoring plan, including a regular reporting system, should be prepared prior to project development. Permanent sampling locations should be established around the Muskeg Mine to monitor wildlife habitat and changes in biodiversity during construction and operation.

Response

Shell intends to develop a wildlife and biodiversity monitoring program for the project. A monitoring program to verify the achievement of wildlife habitat objectives and biodiversity objectives will be undertaken as described in Section 6.2 of the Oil Sands Vegetation Reclamation Committee's report entitled *Guidelines for Reclamation to Forest Vegetation in the Alberta Oil Sands Region.*

Question No.	**77**
Shell No.	**EC 72**
Issue	**Monitoring and Research**

Request

Baseline data is required to address wildlife movement corridors in the Oil Sands Regional Study Area, particularly along the Athabasca River corridor. The effects that the proposed fence line, mine pits, and tailings ponds will have on the breeding activity and movement of all wildlife in the area need to be assessed. Further data is required to identify tributary water courses, ridges, or other linear landscape features that may be important wildlife movement corridors to and from the river valley to evaluate the need for their protection.

Response

Shell will assess wildlife movements within the corridors associated with the LSA as identified in the EIA. Shell is an active participant of the Athabasca Oil Sands Cumulative Effects Assessment Working Group that recognized that effects on movement corridors is a concern. Methods to address this concern have not yet been designed.

Question No.	78
Shell No.	EC 73
Issue	**Monitoring and Research**
Request	The reclamation of consolidated tailings using native species should be further researched to insure successful reclamation. The long-term impacts, if any, of consolidated tailings on vegetation reclamation and on the overall sustainability of habitat and wildlife in the local study area need to be identified.
Response	Shell agrees and will initiate its own research on vegetation reclamation of consolidated tailings. Shell will also evaluate and apply information from the consolidated tailings programs and research being conducted by the other oil sand operators, and through CONRAD.

Question No.	79
Shell No.	EC 74
Issue	**Monitoring and Research**
Request	The proponent is asked to notify Environment Canada if a whooping crane, trumpeter swan, Eskimo curlew, piping plover, Peregrine Falcon, or any other COSEWIC migratory bird species is recovered from the tailings pond. Environment Canada requests that the proponent provide a written report on a regular basis outlining activities of the bird deterrent program.
Response	Shell would be willing to provide such information.

Question No.	80
Shell No.	EC 75
Issue	**Aquatic Biota Issues**
Request	Accurate toxicological assessment of all waters that may be released from the project site is important, however, it is particularly true for release waters from the end pit lake given the portion of the flow of the Muskeg River that will be derived from this source.

Response Predicted acute and chronic toxicity levels from the end-pit lake are well below guidelines. Alternatives to remediate potential toxicity are discussed in EIA Volume 3, Part 1, Section E5. Section 7.1 (End-Pit Lake Discharge) in the Project Update discusses the diversion of the end-pit lake waters to the Athabasca River during the end-pit lake management period when high discharges corresponding to low Muskeg River flows might occur.

Question No. **81**

Shell No. **EC 76**

Issue **Aquatic Biota Issues**

Request Toxicity assessments of project discharges were based on toxic units (TU) derived from acute and chronic lab exposures of less than one week. Environment Canada recommends that data on longer exposures to similar oil sands wastewaters be considered in the toxicity assessment. In particular data should be developed for releases from the end pit lake.

Response Syncrude Base Mine Lake research and monitoring will provide important information for toxicity assessments for the end-pit lake. Shell is committed to working with other operators to proactively address this issue. See also the responses to AEP 151 to 177. Shell will undertake long term toxicity assessment in conjunction with the fish health study (see the response to EC 77).

Question No. **82**

Shell No. **EC 77**

Issue **Aquatic Biota Issues**

Request While TUs are an indication of toxicity, further information is required to assess effects on fish health. "Effects on fish health, other than acute and chronic toxicity, were not included in this assessment" and there is "no data on the effects of CT water on fish health parameters" (p. E 5-24 and 6-24, Vol. 3.1). Longer exposures of fish to similar wastewaters have been done by Suncor, Syncrude and other companies. These data would provide an estimation of sublethal effects and other biological effects not accounted for in the TU acute/chronic assessment. Data on relevant fish health studies should be incorporated into the EIA.

Response Shell, with Syncrude and Suncor, are funding two fish health studies (see the response to DFO 75).

Question No.	83
Shell No.	EC 78
Issue	**Aquatic Biota Issues**

Request

It is stated that residual impacts of PAH accumulation in sediments is "reversible" (Table E5-16, Vol. 3.1). It should be noted that PAHs bound to solids in bottom sediments that are deep and anoxic is not a 'reversible' condition without purposeful action or disturbance such as dredging or stirring.

Response

Error acknowledged. The impact classification should have characterized this potential impact as "irreversible".

Question No.	84
Shell No.	EC 79
Issue	**Aquatic Biota Issues**

Request

It is argued that because 60% of the Muskeg River is now made up of muskeg/overburden drainage and that these waters are non-toxic to aquatic organisms, that operational water releases can also be assumed to be non-toxic (p. E5-23, Vol. 3.1). Environment Canada is not convinced that overburden and muskeg drainage waters from an intact, weather-worn and eroded system will contain the same concentrations of compounds in drainage water from a similar disturbed system. Waters from a disturbed system will have greater exposure to oil sands which may increase their toxicity. Chemistry and toxicity data on drainage from mined and disturbed overburden and muskeg should be provided.

Response

Chemistry and toxicity data on drainage from mined and disturbed overburden and muskeg is provided in EIA Volume 3, Part 2, Appendix V. Syncrude's Aurora mine has regulatory requirements in its provincial Air and Water Approval to monitor the toxicity of these releases and Shell expects similar requirements.

Question No.	85
Shell No.	EC 80
Issue	**Aquatic Biota Issues**

Request

The predicted range of total dissolved solids in the end pit lake discharge is 25% less than the concentration that will reduce the diversity of aquatic macrophytes. However, CT water from consolidation of fine tails "will inevitably affect the characteristics of the biological community in aquatic ecosystems ... perhaps decreasing biodiversity " (p.E16-36, Vol. 3.1). Since end pit lake waters are made up of mostly CT consolidation water, examining the mean concentrations of salts in the end pit lake may underestimate the effects of salts by assuming a completely mixed system. Pockets of toxic salty water may occur along the edges of the end pit lake before mixing occurs. The closure plan map (E16-13) shows that CT water enters will enter the end pit lake in potentially one of the most sensitive areas, the shallow wave-protected littoral zone which is vital habitat for small fish, eggs and fry. Data should be provided on the total dissolved salt concentrations in CT consolidation water, as well as data on the acute and chronic toxicity of this water, to aid in assessing potential impacts. Approximation of the flows and fate of CT consolidation waters as they enter the end pit lake should also be provided. If toxicity is unacceptable prior to mixing, then plans should be considered for removal of the salts or for CT consolidation water treatment, dilution or storage. In addition to addressing salt concentrations in the end pit lake waters, an assessment should also be made of the potential for increased salt concentrations in surrounding soils and the effects of this on wildlife.

Response

Data on TDS and acute and chronic toxicity of individual waters entering the end-pit lake is included in EIA Volume 3, Part 2, Appendix V. Modeled results of TDS are presented in EIA Volume 3, Part 1, Table E5-17. Inflows into the Muskeg River Mine Project end-pit lake are shown in Table 80, and illustrated in Figure 80-1. The relative amount of CT water in the end-pit lake over time is illustrated in Figure 80-2. End-pit lake outflow rates are shown in Figure 80-3 and volumes from 2022 to 2062 in Figure 80-4.

Shell recognizes that many issues require follow-up research and monitoring to ensure that the end-pit lake is environmentally acceptable and can be effectively integrated into the reclaimed landscape. Current reclamation research at Syncrude and Suncor, through CONRAD, is investigating the effect of salt buildup in soils from CT and how that might affect growth of vegetation. Information from this and future work will then provide the foundation for addressing the effects on wildlife.

Table 80: Inflows and Outflows for the End-Pit Lake During Selected Years

	Year						
	filling of the EPL		EPL discharging to Muskeg River				
Water flow (m3/s)	**2023**	**2027**	**2028**	**2032**	**2036**	**2041**	**2046**
Inflow							
Surface runoff	0.2	0.2	0.2	0.2	0.2	0.2	0.2
CT flux water	0.9	0.1	0.08	0.03	0.009	0.009	0
Tailings pond water	0.2	0.3	0.3	0.0	0.0	0.0	0
MFT	0	0.4	0.4	0	0	0	0
Precipitation	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total inflow	1.4	1.1	1.1	0.3	0.3	0.3	0.3
Outflows							
Evaporative loss	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Seepage	0.002	0.002	0.002	0.002	0.002	0.002	0.002
EPL discharge	0	0	1.0	0.2	0.2	0.2	0.2
Total outflows	0.1	0.1	1.1	0.3	0.3	0.3	0.3

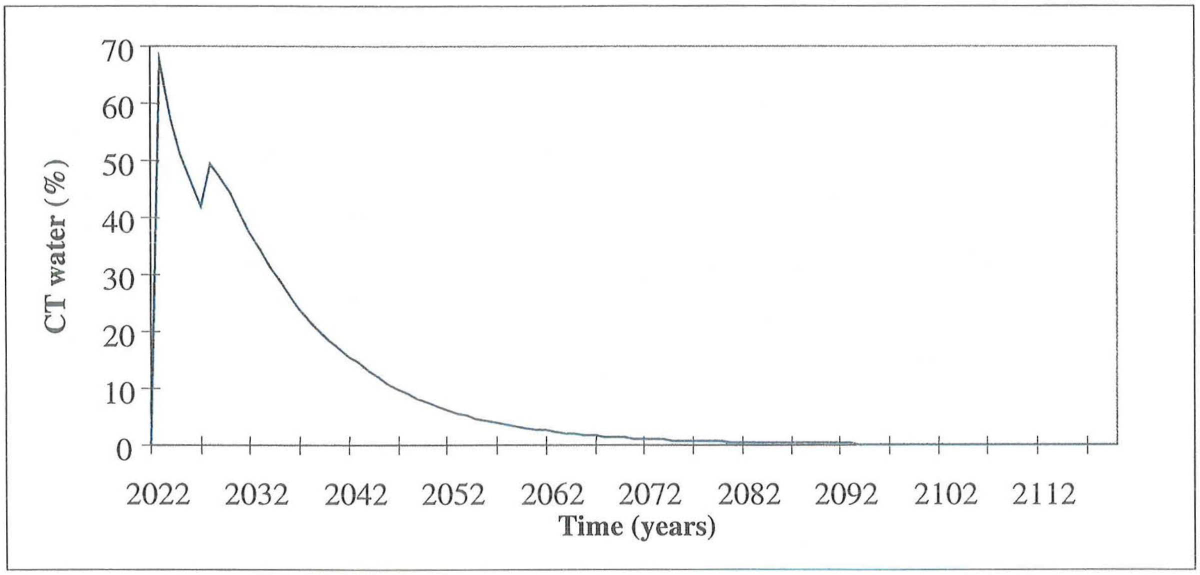

Figure 80-1: Relative Proportion of CT Water in the MRMP End-Pit Lake Over Time

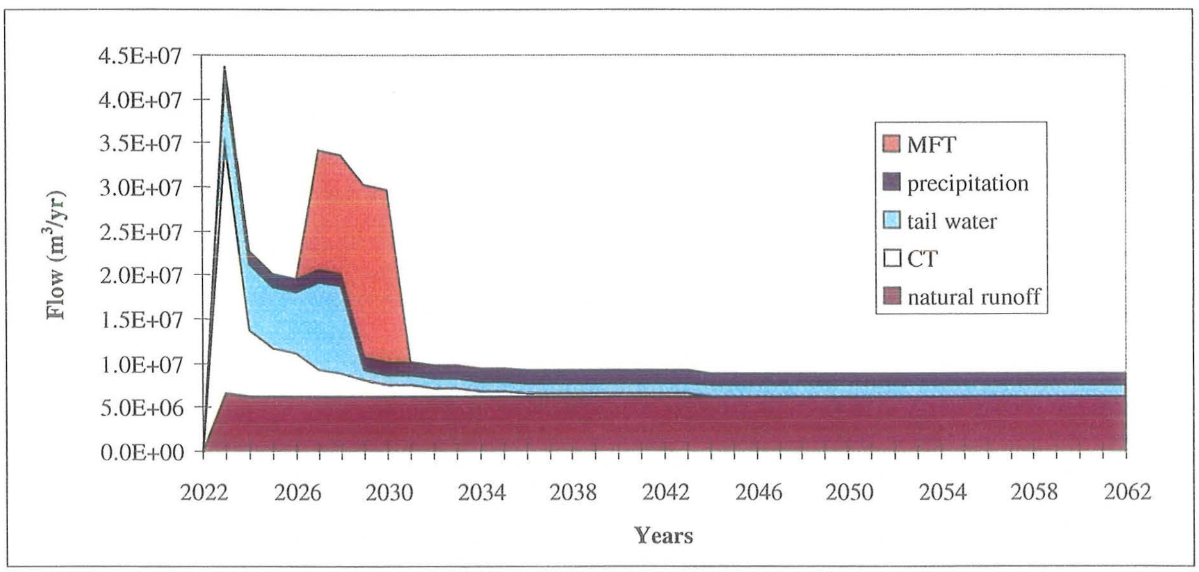

Figure 80-2: Inflows into the MRMP End-Pit Lake from 2022 to 2062

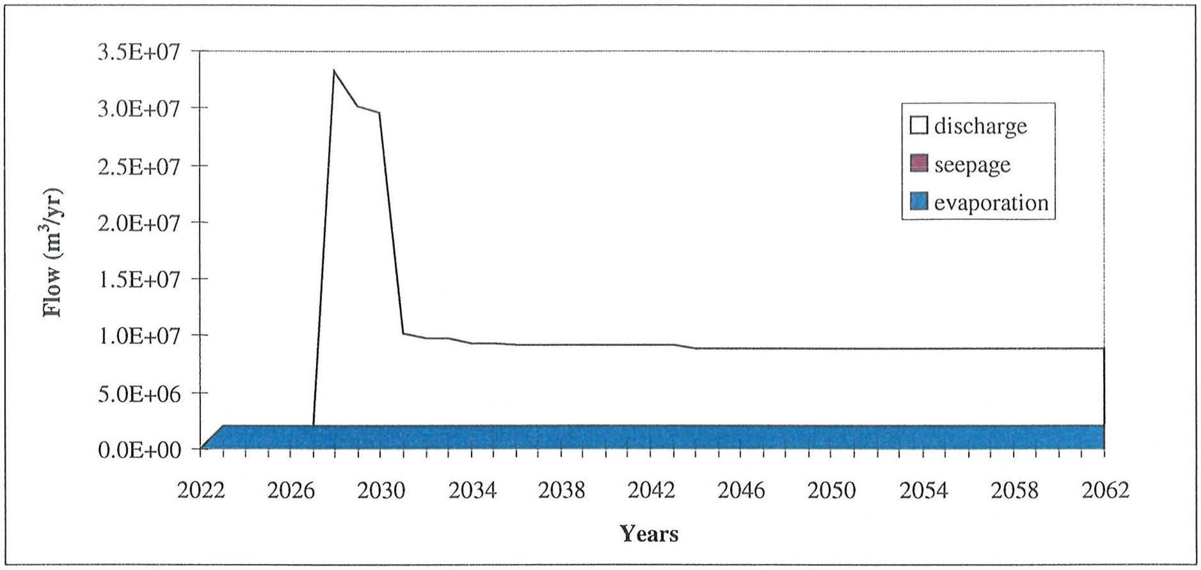

Figure 80-3: Outflows into the MRMP End-Pit Lake from 2022 to 2062

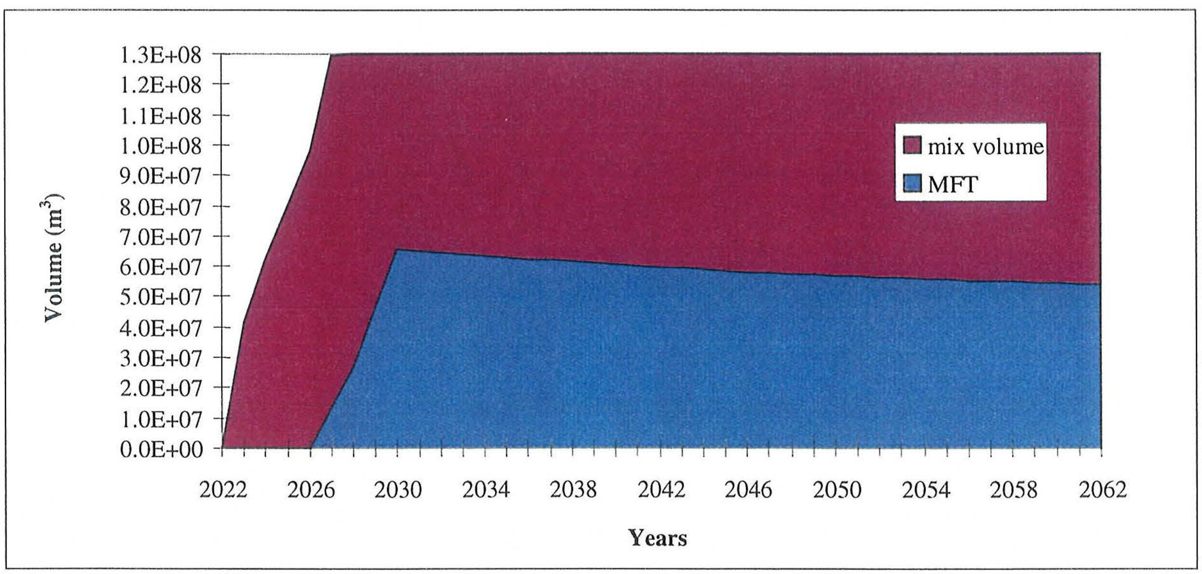

Figure 80-4: MRMP End-Pit Lake Volumes from 2022 to 2062

Question No. 86

Shell No. EC 81

Issue **Aquatic Biota Issues**

Request

Naphthenic acids are expected to reach a high of 73 mg/L, and drop to 2.1 mg/L in 2030, in the end pit lake. Environment Canada studies have shown that fish exposed to Syncrude naphthenic acid (50%) showed 100% mortality at concentrations over 6.25 mg/L. Only 2 of 5 small rainbow trout exposed for 4 days survived exposure to 3.12 mg/L. Naphthenic acid concentrations at 73 mg/L will be acutely toxic and at 2.1 mg/L, they will probably be sublethally toxic and may also be acutely toxic. The toxicity of naphthenic acids in the end pit lake waters needs to be addressed further in the EIA.

Response

Commercial naphthenic acids do not provide a good surrogate for naphthenic acids contained within tailings pond water, consolidated tailings or the end-pit lake. However, acute toxicity of reclamation waters containing measured naphthenic acids to various organisms have been measured and reported (see the response to EC 82).

Natural levels of naphthenic acids of up to 4 mg/L have been measured in the lower Muskeg River (see EIA, Volume 2, Table D5-6). One would assume these levels are not toxic and that natural fauna have adapted to these levels.

However, the toxicity of naphthenic acid is a concern and further research on the effects of naphthenic acids on mammals is currently being conducted under CONRAD.

Question No. 87

Shell No. EC 82

Issue **Aquatic Biota Issues**

Request

There are differences in biological potency between 'aged' and 'fresh' naphthenic acids. In Environment Canada studies, the acids tested were fresh while those on site will be aged. The potential effects of this difference should be discussed in further assessments. Data should be provided on the acute and chronic toxicity of naphthenic acids to plants (algae), invertebrates and fish. Using this data, the end pit lake discharge in 2030 should be assessed to determine if levels in the Muskeg River will be potentially harmful to aquatic life.

Response

Acute and chronic toxicity of reclamation waters containing measured naphthenic acids to plants (algae), invertebrates and fish have been measured (see EIA Volume 3, Part 2, Appendix VII) and used for representing tailings water and CT for the end-pit lake modeling.

Question No. 88

Shell No. EC 83

Issue **Aquatic Biota Issues**

Request

The end pit lake is expected to support a viable ecosystem. Sublethal and acute toxicity data for naphthenic acids is required to determine if this is feasible.

Response

Commercial mixtures of naphthenic acids do not provide a good surrogate for tailings water and CT. Continued acute and chronic toxicity testing and the proposed fish health study will provide results that can be used to refine end-pit lake predictions.

Question No. 89

Shell No. EC 84

Issue **Aquatic Biota Issues**

Request

Benzo(a)pyrene and Benzo(a)anthracene concentrations in end pit lake waters should be compared with water quality guidelines, the acute and chronic toxicity of these compounds, and concentrations at which deleterious effects on fish and fry can be expected. It is not evident in the EIA that this has been done.

Response

Benzo(a)pyrene and benzo(a)anthracene concentrations in end-pit lake waters were compared to human health water quality guidelines in EIA Volume 3, Part 1, Table E5-17. There is no readily available information to describe the acute and chronic toxicity of these compounds to aquatic life.

The information in Table 84 was found to have some relation to aquatic toxicity of PAH.

For reference, the human health carcinogen threshold level assumed for BAP and BAA groups in the EIA was 0.0028 μg/L (10^{-6} cancer risk for both the consumption of fish and ingestion of water).

This information is not sufficient to predict threshold levels of BAA in water for fish. Although it might be concluded that, in the absence of any regulatory threshold guidance levels for effects of BAA or BAP on fish, compliance with established human health threshold levels would reflect the current scientific and regulatory priorities and concerns for these compounds, Shell is, nevertheless, committed to continuing to address this issue through monitoring ultra-low detection levels of PAHs in the water column, sediment in the water column and sediment at existing and proposed RAMP sites (see Section 7 in the Project Update) and other sites as may be judged appropriate.

Table 84: Aquatic Toxicity of PAHs

Compound/ Exposure Medium	Concentration or Range	Observed Effect	Reference
anthracene, water	6 to 12 µg/L for 6 weeks, increased to 12 to 20 µg/L for 3 weeks	• reduced reproductive output in mature fathead minnows • reduced egg and fry survival and teratogenic effects in maternally exposed organisms (in the presence of solar UV radiation) • reduced survival of maternally exposed fry (without solar UV radiation)	Tilghman and Oris (1991)
petroleum-related PAHs, sediment	Total PAHs <1 to >500 µg/g	• reduced number of Melanomacrophage centres (analogues of lymph nodes) in flounder at 25 to 50 µg/g and higher concentrations in fathead minnows	Payne and Fancey (1989)
petroleum-related PAHs, sediment	Total PAHs <1 to >500 µg/g	• biochemical effects (MFO induction, liver fat content) altered at <1 µg/g in fathead minnows • other effects (liver and spleen as % body weight, liver glycogen content, muscle protein) exhibited at 50 µg/g or higher concentrations	Payne et al. (1988)
B(a)P, water	25 µg/mL, exposed as embryo	• not biologically significant differences in routine metabolism of embryos, hatching of eggs, alevin endurance, or whole life cycle endpoints for coho salmon • results inconsistent with an earlier study by same authors (Ostrander et al. 1988) that demonstrated effects of B(a)P from exposure of fry, which is a more sensitive life stage	Ostrander et al. (1989)
total PAHs in water	300 µg/L for acute toxicity in saltwater	• available data for PAHs indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 300 µg/L and would occur at lower concentrations among species that are more sensitive than those tested". • no data are available concerning the chronic toxicity of PAHs to sensitive saltwater aquatic life. • limited data available for freshwater organisms does not permit a statement concerning acute or chronic toxicity	US EPA 1986

Question No. 90

Shell No. EC 85

Issue **Aquatic Biota Issues**

Request

In assessing the toxicity of operational and reclamation waters it has been assumed that waters upstream of the discharge will have no toxicity (p.E5-25). However, there are 5 pulp mills and several towns upstream of this project. The Northern Rivers Basin Study Report (NRBS) has evidence that pulp mill contaminants are deposited in the delta and Great Slave Lake. NRBS studies have also revealed "that nutrient inputs from pulp mills and municipalities have enriched aquatic communities immediately downstream of their outfalls..." and "While this initial effect is localized, nutrients may eventually accumulate in downstream sections of the rivers and cause nutrient / dissolved oxygen difficulties in the long term" (NRBS, 1996).The toxicity of upstream waters should be assessed to account for possible influences on the toxicity of discharges from this project.

Response

Only Microtox data for upstream of oil sands operations are available for further analysis (Golder 1996). No toxicity was evident from these samples. As participants of RAMP, federal government representatives can make recommendations on the design of the water quality sampling of the Athabasca River.

Pulp mills and oil sands releases have very different compositions. No synergistic effects are expected.

Oil sands operations will not significantly increase nutrient loading to the Athabasca River. Pulp mills add nutrients to their stabilization systems. No dissolved oxygen (DO) problems are predicted for this stretch of the Athabasca River. The potential for DO problems has only been demonstrated above Grande Rapids, well upstream of Fort McMurray. Oil sands releases do not contain levels of oxygen-demanding substances that would contribute to any lowering of dissolved oxygen levels in the Athabasca River.

Question No. 91

Shell No. EC 86

Issue **Aquatic Biota Issues**

Request

It is proposed that monitoring programs will cease if no effects on the Muskeg River are observed during low, medium and high flow years. Scientific justification is required to discontinue monitoring based on three 'no effect' events. Statistical design is required to determine how many no effect events, for each type of flow year, would be required to ensure that there is no trend; single occurrences are not sufficient for determining that monitoring be discontinued. If the decision to cease monitoring cannot be statistically justified, monitoring should continue for the life of the project and following closure. A clear definition of 'no effects' is required for these discussions.

Response Comments acknowledged. These suggestions are reasonable. Shell expects to work with provincial and federal regulators as well as stakeholders to help define future basin-wide monitoring programs.

Question No. 92

Shell No. EC 87

Issue **Water Issues – Effects on Muskeg River Thermal Regime**

Request In Section E5 it is concluded that effects on the thermal regime of Muskeg River will be neutral and negligible. Based on measurements, the modeling to predict the thermal effects, uses a groundwater inflow temperature of 2 to 4C in the winter. Given that groundwater temperatures approximate the mean annual ambient temperature, ground water inflow temperatures during the winter would be expected to be in the range of 4 to 6C. Therefore the proponent should verify the accuracy of their measurements. The loss of this thermal input could create a greater cooling effect than predicted by the model. There may be earlier freezing of shorelines in the winter and later thawing in the spring, causing some shoreline habitat to be alienated. Thermal modeling should be conducted again using groundwater inflow temperatures of 4 to 6C.

Response Higher winter water temperature would be expected to result in warming of river water during that season, rather than a cooling effect.

Because predicted contributions of the Muskeg River Mine Project to seepages (groundwater) reaching the Muskeg River in the winter are small, use of the higher winter temperatures would not affect model results presented in the EIA (see EIA Volume 3, Part 1, Section E5).

Rerunning the CEA temperature models using a year-round, constant groundwater temperature of 5°C showed increases in predicted winter river water temperatures of up to 2°C relative to those reported in EIA Volume 4, Sections F5 and G5, and no changes in the open-water season. However, the utility of this re-assessment is questionable, because the Muskeg River is largely groundwater-fed in the winter (under baseflow), an addition of more groundwater in the form of seepages, or a change in the origin of the groundwater entering the river, would probably not affect river water temperature.

Question No. 93

Shell No. EC 88

Issue **Groundwater**

Request The discussion of the physical hydrogeology of Lease 13 is very general and based upon a limited number of data points given the size of the study area. Because of the high degree of complexity of the stratigraphy in this area, further delineation of hydrogeological characterization of the area is required. It is recognized that the data required to generate detailed three dimensional models would be prohibitive to collect however, further groundwater monitoring is warranted. The company should implement a broadly spaced ground water monitoring system to measure water levels and hydrochemistry in all the major aquifers in the local study area, from the LaLoche formation upward to the Quaternary formation. This system should consist of piezometer nests, with at least one piezometer in each of the major ground water aquifers identified. The buried preglacial valley running across the area should also be drilled and instrumented at several places in the regional study area. Both water quality and flows should be measured.

Response

The reviewer's comment on the need for groundwater monitoring is acknowledged. Additional hydrogeologic data collection continued in the winter 1997-98 field program, and is expected to resume in the winter of 1998-99. The monitoring requirements specified by the reviewer are compatible with those identified in the conceptual monitoring program discussed in the EIA. See also the response to DFO 45. Design of a detailed groundwater monitoring program is expected to be developed in conjunction with other detailed engineering studies for the mine. However, the elements of the groundwater monitoring program will incorporate those items identified by the reviewer.

Question No. **94**

Shell No. **EC 89**

Issue **Groundwater**

Request

The water quality of drainage into the open pit mine has not been adequately addressed. The proponent must ensure that there will be no release of high ionic strength ground water to surface water. More data is required on hydraulic conductivity and storage of the aquifers affected. Collection of data on these physical parameters should be incorporated into the ground water monitoring network. Given the size of the study area, the number of monitoring stations for these parameters should not be less than twenty, and piezometers should have data loggers. Data should be collected over the life of the project until stabilization occurs following reclamation.

Response

Drainage into the mine pit will be not be released to surface water, but will be used for process water or transferred into the water recycle system for the plant.

Additional data on the hydraulic properties of aquifers were collected in the winter 1997-98 field program, and is expected to continue in the winter 1998-99 hydrogeologic field program.

The reviewer's requirements for groundwater monitoring are noted, and will be incorporated into the groundwater monitoring program when detailed design is done. See the response to DFO 45 for Shell's initially proposed groundwater monitoring network.

Question No. 95

Shell No. EC 90

Issue **Groundwater**

Request

It is recognized that given the timing the amount of predevelopment baseline data will be limited, but it will assist in determining the quantity and quality of water that will have to be managed over the life of the project. Monitoring data collected prior to and during project development should be incorporated into the preparation of reclamation plans to reduce long term hydrological impacts.

Response

Comments acknowledged.

Question No. 96

Shell No. EC 91

Issue **Water Management Plan**

Request

The tailings pond, the recycle pond and the raw water storage ponds will be formed by erecting perimeter dykes. Details on construction methods should be provided along with a discussion of the probability of dyke failure and failure prevention.

Response

Information on pond design and construction will be available in the future as designs are developed. All designs must be submitted to the appropriate regulatory authorities for review and approval before permitting and construction. For tailings settling pond information see Volume 1, Section 6.1 (Overview of Tailings Operations) and 6.3 (Tailings Management Plan).

Question No. 97

Shell No. EC 92

Issue **Water Management Plan**

Request

The water reclamation plan includes construction of a ditch at the perimeter of the tailings pond to collect seepage. During mine decommissioning, seepage will be collected and will flow through a series of wetlands before being discharged to the Athabasca River (page 31). A full explanation of how the tailings decant water is going to be detoxified during residence in the end pit lake is required. A detailed discussion and explanation of the processes involved, their effectiveness and timing requirements, and the water quality parameters that they address, is required. This should include a discussion of the toxicology of the tailings decant waters compared with background conditions. The Fine Tailings Consortium has published a number of studies on the detoxification of tailing waters; these findings should be considered here.

Response

This is a large subject area which continues to be the focus of numerous studies. Shell is aware that information from these studies is critical in determining the necessary water management requirements to ensure that the environment is protected and regulatory requirements are met, as discussed in the EIA. This information has been used where applicable for modeling assumptions and closure discussion. However, a detailed review of the detoxification mechanisms and processes is outside the scope of this EIA.

Research associated with water-capped fine tailings by Syncrude and Suncor, as described in the Fine Tailings Fundamentals Consortium (FTFC) (1995) report *Water Capped Fine Tails Lakes,* summarizes results from research conducted on the toxicity of fine tailings and pond and pore water, re-suspension of fine tailings and of the contaminant's fate. This material was used as evidence that the concept of a water-capped fine tailings lake and by similarity, an end-pit lake, is viable.

Question No. **98**

Shell No. **EC 93**

Issue **Water Management Plan**

Request

The proponent should clearly define consolidated tails, the process that will be used to create CT, and the physical, chemical, bacteriological and toxicological properties of the resulting products

Response

Detailed information on CT water is contained in the recently released report on CT (Golder 1998).

Question No. **99**

Shell No. **EC 94**

Issue **Water Management Plan**

Request

The section on water balance inflows, outflows and changes in storage after mine closure is confusing (page 42). For example, the plan appears to be for the transfer of 17 million m3 of water from the tailings pond and 19 million m3 of CT porewater to the end pit lake. CT porewater will come from the pit area. Will the CT porewater be gradually released so that it can be handled on an on-going basis? Is 19 million m3 the total quantity of CT porewater expected? A concise explanation of the sequence of events for water transfer and treatment should be provided. The proponent should clarify where the CT porewater will be released and if it is to the end-pit lake, how they will provide for sufficient residence time for detoxification of this water.

Response

Table 3, on page 34 of the *Water Management Plan for the Muskeg River Mine Project* provides a concise summary of water and MFT transfer to the end-pit lake.

With reference to CT porewater, 19 Mm^3 represents the volume of CT porewater which will have accumulated in the reclaimed CT area at the end of mine operations in 2022. All of this water will be pumped to the end-pit lake in 2023, as indicated in Table 3. CT deposits will continue to release porewater at variable rates until about 2043. These waters will flow through reclamation wetlands and into the end-pit lake.

Passive CT porewater treatment will occur both in the reclamation wetlands and in the end-pit lake. However, the water and MFT transfer rates detailed in Table 3 that biodegradation in the end-pit lake alone would be sufficient to remediate the CT porewater. Adopting this conservative approach should ensure that end-pit lake outflows are non-toxic.

Question No. **100**

Shell No. **EC 95**

Issue **Water Management Plan**

Request

On the section on water balance it is stated that after 2030 "MFT will be pumped to the end-pit lake where it will displace accumulated water. Large releases from the end-pit lake to receiving streams will occur as a result of this transfer of MFT beginning in 2027 and ending in 2030. The rates of outflow from the end pit lake to the Muskeg River are predicted as starting at 0.9 m3/s and being reduced to 0.22 m3/s within four years (pages 33 to 35). After 2030, the inventory of water in the mine disturbed area will remain relatively constant and slow releases of CT pore water will occur until 2044." . The proponent should describe the expected toxicity of the water released from the end pit lake during and after MFT transfer. The Water Management Plan should include a discussion of the data available to support predictions of flow rates.

Response

The end-pit lake will begin discharging to the Muskeg River in 2028, when chronic and acute toxicity levels in the outflow waters are projected to be 0.18 TUc and 0.15 TUa, respectively. MFT transfer will be complete in 2030. Acute and chronic toxicity levels in end-pit lake outflow waters in 2031 are projected to be 0.1 TUa and 0.19 TUc, respectively.

The data used to estimate water flow rates are provided in Appendix II of the *Water Management Plan for the Muskeg River Mine Project* including data input from AGRA Earth and Environmental (Table II-1) and area and drainage inputs for mine water balance (Table II-2).

Also see Section 7.1 (End-Pit Lake Discharge) in the Project Update, which describes Shell's new approach to reduce the volume of water released from the end-pit lake to the Muskeg River to ensure that there are no detrimental effects on aquatic resources.

Question No. 101

Shell No. EC 96

Issue **Water and Sediment Quality**

Request

To assist in interpreting results and assessing impacts on sediment and water quality, Environment Canada requires clarification on a number of points. The following information deficiencies in the EIA should be addressed.

96.1 Clarification of the detection methods and limits used for organic compounds is required.

Response

96.1 Table 96-1 describes the analytical methods used to generate the organic data discussed in the Muskeg River Mine Project EIA, and the typical detection limits associated with each test method.

Request

96.2 The proponent is requested to provide detailed explanations of, or references for, the surface water related models referred to on pages E5 to 13, Vol. 3.1. A summary of the modeling results should be provided.

Response

96.2 Four water quality models were mentioned in EIA Volume 3, Part 1, page E5-13. They include the:

- Small Streams Model
- Athabasca River Model
- End-Pit Lake Model
- Thermal Regime Model

All of these models are briefly described in EIA Volume 3, Part 1, Section E5.4.4. Further information about the Athabasca River model is available in Golder (1996). This is the same model that was subject to detailed review by Brian Brownlee (Environment Canada) in 1996 as part of the Steepbank Mine EIA.

The assumptions used in each model are described in EIA Volume 4, Appendix V, Sections V-1.1.4 to V-1.1.8.

Detailed modeling results are included in EIA Volume 4, Appendix V, Section V-1.2 and Appendix XII, Section XII-1.3.

Request

96.3 It is not clear in the EIA whether water quality exceedances are being compared with provincial or federal guidelines (s. E5, Vol. 3.1). The proponent should compare predicted concentrations with both federal and provincial water quality guidelines that are applicable to the protection of aquatic life.

Response

96.3 Projected water quality concentrations were screened against a list of guidelines complied in accordance with AEP's *Protocol to develop Alberta water quality guidelines for protection of freshwater aquatic life* (AEP 1996). Therefore, the guidelines used in the Muskeg River Mine Project EIA are a combination of federal and provincial guidelines.

Modeling results were compared to CCME guidelines and are summarized in Table 96-2 for the Athabasca River and Table 96-3 for the Muskeg River. In addition to substances already discussed in the Muskeg River Mine Project EIA, beryllium, silver, molybdenum, and selenium were found to exceed CCME guidelines under certain flow conditions and test scenarios. These values were not discussed in the Muskeg River Mine Project EIA, because the U.S. EPA and ASWQO guidelines used in the Muskeg River Mine Project EIA are higher than the respective CCME values.

Request 96.4 It is not clear what phase of the project the predicted concentrations of substances shown in Tables 5-4 to 5-7, are for. This should be clarified. The predicted concentration should be provided for the development, operation and decommissioning phases of the project.

Response 96.4 The results presented in these tables represent the highest predicted values that result in exceedances of water quality guidelines across all time snapshots modeled. Detailed results for all substances for all time snapshots are contained in EIA Volume 3, Part 2, Appendix V.

Request 96.5 The background levels for some parameters exceed the Canadian Water Quality Guidelines (E5-18, Vol. 3.1). The EIA should address how much the project will increase the concentration of these substances beyond background levels.

Response 96.5 In EIA Volume 3, Part 1, Tables E5-4 to E5-7 illustrate the incremental effect of the project. Each table describes existing conditions in the receiving water and the projected substance concentration when the Muskeg River Mine Project is included.

Beryllium is the only substance that naturally exceeds CCME guidelines. This element was not included in Tables E5-4 and E5-5 because it was not found to exceed the guidelines used in the assessment. Beryllium concentrations are shown in EIA Volume 3, Part 2, Appendix V, Tables V-5 and V-6.

The Muskeg River Mine Project is not expected to measurably affect substance concentrations in the Athabasca River (see EIA Volume 3, Part 1, Tables E5-4 and E5-5 and EIA Volume 3, Part 2, Tables V-5 and V-6). Iron is the only element whose concentrations will noticeably increase as a result of the Muskeg River Mine Project (see EIA Volume 3, Part 1, Tables E5-6 and E5-7). The significance of this result is discussed in Section E5.5.2.

Request 96.6 Some residual solvent will remain on the consolidated tailings deposited into the end-pit lake. Clarification is required on the partitioning of the solvent between the tailings and lake water, and the rate of volatilization of the residual pentane and hexane mixed with water.

Response 96.6 Consolidated tailings are not being considered for placement in the end-pit lake. However, CT flux and seepage will be directed to the end-pit lake. It is not expected that appreciable levels of residual pentane and hexane will be present in the end-pit lake because of the long time elapsed between when any process streams would have come into contact with the extraction process and when they would end up in the end-pit lake. See also the response to EC 115.

Residual pentane and hexane levels will be measured during the pilot plant operation scheduled to begin in the summer of 1998.

Request 96.7 A definition of the term "group", as applied to benzo(a)pyrene and benzo(a)anthracene throughout the EIA, is required.

Response 96.7 The method is described in the water releases report (Golder 1996) and is presented in Attachment 4 at the end of the DFO responses.

Request 96.8 A map of the water quality sampling stations, in relation to the mine site, is required.

Response 96.8 In Golder (1997), Figure 2.2-1 shows the location of the water quality sampling sites for the Muskeg River Mine Project EIA baseline program. In Golder (1997) Table 2.2-1 details the origin of the sampling sites illustrated in Figure 2.2-1.

Request 96.9 For surface water quality descriptions, information is required on the number of samples analyzed, the number of samples exceeding guidelines, and the maximum, minimum and median values for each parameter (Tables D5-2 to10, Vol. 2).

Response 96.9 In Golder (1997), Tables V-1A through V-5 detail the number of samples analyzed and the minimum, maximum and median values for each parameter. Table 96-4 summarizes the number of samples found to exceed CCME guidelines.

Table 96-1: Analytical Methods used to Determine Organic Concentrations in Sediments and Waters

Medium	Organics	Methods[a]	Detection Limits[b]
Sediments	PAHs and alkylated PAHs	EPA3540/8270	0.003 or 0.02 ppm depending on the individual compound
Water	PAHs and alkylated PAHs	EPA3540/8270	0.02 or 0.04 ppb depending on the individual compound
	PANHs and alkylated PANHs	EPA3540/8270	0.02 ppb
	Phenolics	modified EPA3510/8270	0.1, 0.2 or 2 ppb depending on the individual compound
	Recoverable hydrocarbons	APHA 5520F	0.5 mg/L
	Total phenolics	EPA420.2/4-AP	0.001 mg/L
	Naphthenic acids	FTIR	1 mg/L

[a] These are methods currently in use at EnviroTest Laboratories; they may be different from those used to derive data older than 1995.
[b] Detection limits may vary from sample to sample depending on volume of sample and other test conditions.

Table 96-2: Substances Projected to Exceed CCME Guidelines in the Athabasca River

Scenario	Flow Condition	Exceedance[a]	Comments
Shell only	7Q10	-	nothing new
	mean open water	Al, Be, Fe, Mo	Be - background exceedance and Mo - EPL
Aurora only	7Q10	Fe	nothing new
	mean open water	Al, Be, Fe	Be - background exceedance
CEA	7Q10	Fe	nothing new
	mean open water	Al, Be, Fe, Mo	Be - background exceedance and Mo - EPL
RDR	7Q10	Fe	nothing new
	mean open water	Al, Be, Fe, Mo	Be - background exceedance and Mo - EPL

(a) Al = aluminum, Be = beryllium, Fe = iron and Mo = molybdenum.

Table 96-3: Substances Projected to Exceed CCME Guidelines in the Muskeg River

Scenario	Flow Condition	Exceedance[a]	Comments
Shell only	7Q10	Al, Be, Fe	Be - muskeg & overburden dewatering
	mean open water	Al, Fe, Be, Mo, Ag	Be, Mo and Ag - end pit lake (EPL)
Aurora only	7Q10	Al, Be, Cd, Cr, Cu, Fe, Se, Mo, Ag	Be - muskeg & overburden + sand seepage; Mo and Ag - sand seepage; Se - muskeg & overburden dewatering
	mean open water	Al, Be, Fe, Mo, Se	Be and Mo - sand seepage; Se - muskeg & overburden dewatering
CEA	7Q10	Al, Be, Cd, Cr, Cu, Fe, Mo, Se, Ag	Be - muskeg & overburden + sand seepage; Mo and Ag - sand seepage; Se - muskeg & overburden dewatering
	mean open water	Al, Be, Fe, Mo, Ag, Se	Be - muskeg & overburden + sand seepage/EPL; Mo and Ag - sand seepage/EPL; Se - muskeg & overburden dewatering
RDR	7Q10	Al, Be, Cd, Cr, Cu, Fe, Mo, Se, Ag	Be - muskeg & overburden + sand seepage; Mo and Ag - sand seepage; Se - muskeg & overburden dewatering
	mean open water	Al, Be, Fe, Mo, Se, Ag	Be - muskeg & overburden + sand seepage/EPL; Mo and Ag - sand seepage/EPL; Se - muskeg & overburden dewatering

(a) Al = aluminum, Be = beryllium, Cd = cadmium, Cr = chromium, Cu = copper, Fe = iron, Mo = molybdenum, Se = selenium and Ag = silver

Table 96-4: Samples Collected Which Exceeded CCME Guidelines

Sample location[a]	Season	Substance and number of samples > CCME[b]
Athabasca River		
up from Fort McMurray	winter	Al - 12, Cd - 4, Cu - 2, Hg - 5
	spring	Al - 11, Cd, 1, Cu - 3, Fe - 3, Hg - 3
	summer	Al - 31, Be - 3, Cr - 1, Cu - 9, Fe - 6, Zn - 2
	fall	Al - 11, Fe - 2
near Donald Creek	winter	-
	spring	Al - 2, Be - 1, Fe - 2, Zn - 1
	summer	Al - 1, Fe - 1, Zn - 1
	fall	Al - 2, Cu - 1, Fe - 2, Zn - 1
below existing oil sands	winter	-
	spring	Al - 2, Cu - 2, Fe - 2, Zn - 1
	summer	Al - 2, Be - 1, Cu - 2, Fe - 2, Pb - 2, Zn - 1
	fall	Al - 1, Fe - 1, Zn - 1
below Fort Creek	winter	Cd - 5, Fe - 8, Zn - 2
	spring	Al - 1, Cu - 1, Fe - 1, Zn - 1
	summer	Al - 1, Be - 1, Cd - 2, Cu - 3, Fe - 1, Zn - 3
	fall	Al - 1, Cd - 1, Fe - 1
Muskeg River		
mouth	winter	Cd - 1, Fe - 11, Hg - 2
	spring	Al - 1
	summer	Be - 1, Cu - 2
	fall	Al - 1, Cd - 2, Fe - 4, Ag - 2
lower	winter	Al - 4, Fe - 4, Hg - 2
	spring	Al - 2, Hg - 2
	summer	Al - 3
	fall	Al - 2, Hg - 5
upper	winter	Al - 2, Fe - 1, Hg - 1
	spring	Al - 1, Fe - 4, Hg - 1
	summer	Fe - 4
	fall	Al - 1, Fe - 3, Hg - 1
Jackpine Creek		
mouth	winter	Al - 1
	spring	Al - 2, Fe - 1
	summer	Al - 2, Cu - 1, Fe - 4, Se - 2, Zn - 1
	fall	Cu - 1, Fe - 5
lower	winter	Hg - 1
	spring	Al - 1
	summer	Fe - 2, Se - 2, Zn - 1
	fall	Al - 1, Hg - 2
upper	winter	Al - 3, Fe - 2, Hg - 2
	spring	Al - 3, Be - 1, Fe - 5
	summer	Al - 5, Fe - 2, Zn - 1
	fall	Al - 3, Cd - 1, Fe - 2, Ag - 1, Zn - 1
Muskeg Creek	winter	Al - 2, Fe - 4, Hg - 2
	spring	Al - 2, Fe - 3
	summer	Al - 1, Fe - 4, Zn - 1
	fall	Fe - 3, Hg - 1, Ag - 1
Shelly Creek	winter	Al - 2, Fe - 1
	spring	Al - 1
	summer	Fe - 2, Pb - 1, Zn - 1
	fall	-

Table 96-4: Samples Collected Which Exceeded CCME Guidelines (cont'd)

Sample location[a]	Season	Substance and number of samples > CCME[b]
Upper Muskeg Creek	winter	Al - 1, Fe - 4
	spring	Fe - 2
	summer	Fe - 6, Se - 3, Zn - 3
	fall	Be - 1, Cd - 1, Fe - 5, Pb - 1
Isadore's Lake	winter	Al - 1, Fe - 1
	spring	-
	summer	Pb - 1
	fall	Cd - 1, Cu - 1
Mills Creek	winter	-
	spring	Fe - 1
	summer	-
	fall	

(a) Site descriptions match those used in Figure 2.2-1.
(b) Al = aluminum, Be = beryllium, Cd - cadmium, Cr - chromium, Cu = copper, Fe = iron, Pb = lead, Hg = mercury, Se = selenium, Ag = silver, Zn - zinc, - = no data collected.

Question No. 98

Shell No. EC 97

Issue **Water and Sediment Quality**

Request

It is not clear whether there is discharge from the tailings pond during the operational phase of this project. In various sections of the EA it is indicated that this project will have zero discharge, and in others it is suggested that there may be discharges. For example, it is stated that "release waters will be held naturally in wetlands or lakes for at least one year" (p. E5-33, Vol. 3.1). Clarification is required on whether there will be discharge to the Muskeg and Athabasca Rivers. If there is discharge, information is required on the timing, volumes, and quality of discharged water. The location and descriptions of referenced wetlands and lakes should be provided.

Response

There will be no direct discharge from the tailings settling pond during operation. The only discharge will be at closure to the end-pit lake. Tailings pond seepage will be collected in a perimeter ditch and recycled during operation. The perimeter ditch will be enhanced with wetlands at closure (to provide greater than one year retention time) and directed to the Athabasca River, as described in the EIA. This discharge was accounted for in the Athabasca River modeling. The location and description of the perimeter ditch and associated wetlands is provided in EIA Volume 3, Part 1, Section E16, Figure E16-2.

Question No.	**99**
Shell No.	**EC 98**
Issue	**Water Quality**

Request

A number of mitigation options are available for reducing toxicity and meeting water quality guidelines (E5-38, Vol. 3.1). A discussion of the various options that will be incorporated into this project should be included in the EIA. An explanation of options considered but not incorporated into project plans should also be provided. Options considered should include filling in the end pit lake with overburden material and sealing tailings pond sediments with non-contaminated colloidal clay before placement in the lake

Response

The purpose of listing the options in EIA Volume 3, Part 1, page E5-38, was to demonstrate that fall-back alternatives are available. These would be incorporated if necessary, but are not currently planned. Additionally, directing the end-pit lake water, or a portion of it, into the Athabasca River during periods when the flow of the Muskeg River is low or otherwise affected by thermal changes, is discussed in Section 7.1 (End-Pit Lake Discharge) in the Project Update.

Filling in the end-pit lake with overburden material and sealing tailings pond sediments with non-contaminated colloidal clay before placement in the lake is not considered an economically viable option.

Question No.	**100**
Shell No.	**EC 99**
Issue	**Water Quality**

Request

The possibility of spills and accidental releases of contaminated water to the Athabasca and Muskeg River basins, due to failure of retention structures, pipeline breakages and flooding of storage ponds has been adequately addressed. Environment Canada acknowledges that the risk of tailings pond breach is remote, and that the berms will be monitored by a review board. Environment Canada recommends that a description of the monitoring plan be provided and that an outline of the emergency response plan for spills and releases also be included in the EIA.

Response

Shell will provide additional spill response plans as a condition of its regulatory approvals.

Volume 1, Section 16, details the types and quantities of materials involved with the Muskeg River Mine.

Accidental releases at the Muskeg River Mine will be prevented and controlled through best management practices, spill prevention procedures and emergency spill response planning. As part of its environmental management and emergency response procedures, Shell will:

- maintain an on-site spill response team with appropriate spill response equipment, including booms, pumps and other equipment currently in place at existing oil sands operations
- enter into mutual aid agreements with Suncor, Syncrude and the Regional Municipality of Wood Buffalo to increase the efficiency of spill containment and clean-up
- develop, in co-operation with the Regional Municipality of Wood Buffalo, a public consultation and information distribution system for keeping the public informed in the unlikely event of a spill
- establish a routine monitoring and maintenance program for all mine structures and equipment
- incorporate appropriate construction practices and engineered structures at river crossings to protect aquatic life and maintain existing water quality

More detailed descriptions of Shell's spill prevention and management plans will be provided as required by the provincial approvals process.

Suncor and Syncrude both maintain trained spill response personnel and equipment. They also have established emergency response plans and execute regular monitoring and maintenance of their respective mine structure and equipment. Shell will institute similar spill prevention and spill response programs. Given the proactive approach of existing, approved and planned oil sands developments towards spill avoidance and rapid containment and clean-up, in the unlikely event that a spill occurred, it would have a limited effect on the aquatic environment.

Question No. **101**

Shell No. **EC 100**

Issue **Sediment Quality**

Request PAHs are of particular concern given their presence in oil sand deposits. Sediment analyses should include comparison with all of the parameters covered by the Canadian Sediment Quality Guidelines for Polycyclic Aromatic Hydrocarbons (Environment Canada, 1995).

Response Interim Canadian Freshwater Sediment Quality Guidelines are listed in EIA Volume 2, Table D5-1. These guidelines were compared with existing sediment quality data from the oil sands area, and the results of the comparisons are shown in Table D5-3. Because only the exceedances are shown in this table, not all PAHs with available guidelines are listed.

Question No. 102

Shell No. EC 101

Issue **Sediment Quality**

Request

There will be exceedances of the benzo(a)pyrene and the benzo(a)anthracene group guidelines (Table E5-6, Vol. 3.1) for the end pit lake. These exceedances are of concern if water from this lake is discharged; it has previously been noted that it is unclear in the EIA whether this water will be discharged. The proponent notes that guideline exceedances for PAHs are probably not realistic as these substances would precipitate in the end pit lake. Environment Canada agrees with this assessment once the tailings pond has closed and the end pit lake is filled with water. However, when the tailings pond (lake) is in operation, factors determining the fate of these substances may change. The end pit lake will contain the presence of residual hexane and pentane. Both of these PAH groups are soluble in many organic solvents. The presence of residual solvent in the tailings may have an impact on the preferential sorption of these compounds to particulate and colloidal material. Preferential sorption must be considered in the analyses before it can be determined that all of the heavier PAHs will be bound to sediment when the tailings pond is in operation.

Response

As indicated in EIA Volume 3, Part 1, page E5-22, follow-up human health risk assessment (Section E12) indicated that the PAH levels projected are below human health threshold levels. End-pit lake water is scheduled to be discharged to the Muskeg River (or Athabasca River), as described in Section 7.1, (End-Pit Lake Discharge) in the Project Update, starting in 2028.

The water quality modeling assumed that all PAHs entering the lake would also be discharged from the lake at concentrations consistent with the degradation rates applied and the residency associated with each stream entering the lake. In addition, Shell notes that if such a mechanism were operating, it would apply to the naphtha being used as a diluent at current tailings pond operations. Tailings and CT water used for the Muskeg River Mine Project assessment would, therefore, have included PAH levels consistent with that theory.

MUSKEG RIVER MINE PROJECT
Information Request

EUB No.	Exhibit No.
Information Requested By: PARKS CANADA	
Date of I.R. June 23, 1998	

Question No. 1

Shell No. PC 1

Issue **Cultural Resource Impact Review**

Request

Section D13 outlining the cultural resource background for the area is very thorough and gives a good sense of the nature and quantity of resources previously identified from various assessments conducted in the past. The use of an Archaeological Potential Model based upon these past archaeological investigations in the study area provides an excellent basis for the cultural resource assessment. In addition, the survey methodology for assessing the presence of sites is more than adequate given standard archaeological inventory practices. As a result, the inventory of the archeological sites and understanding of potential remains in the study area is more than sufficient. Furthermore, the various project activities such as forest clearing, excavation of drainage ditches, installation of wells, trenches for pipeline installation, grading for facility construction, road construction, and muskeg and overburden removal are identified and their potential effects on cultural resources clearly outlined.

The only concern which arises from the assessment revolves around the approach used to measure the magnitude of significance and the associated effect this appears to have had on the study's ability to conduct a cumulative assessment of impacts to cultural resources.

The Impact Classification Definitions contained in table E13-1 on page E13-7 define what is meant by high, moderate, low, or negligible impacts. However, these measures of significance provide no indication as to whether a combination of low or moderate impacts could constitute a higher order of magnitude with regard to overall cultural resource impacts in a broader regional setting. For example it is stated on page E13-8 that overburden removal in the development area will result in removal of all archaeological sites. The magnitude of impact for this phase of the project could be based on the significance of each individual site affected even though it is mentioned that "the prehistoric sites in the LSA represent the densest known concentration yet identified in Alberta's forested regions". It is recognized that the Environmental Assessment Statement attempts to address this problem by developing a range of evaluation criteria and a hierarchy of mitigation measures designed to ensure that samples are recovered, conserved and analyzed to represent the following:

- non-typical historical behavior patterns;
- typical or representative components of the recognized historical land use patterns throughout the project area;
- palaeo-environmental information that would provide important contextual data to elucidate prehistoric land use patterns;

- correlate and interpret this information so that a major contribution to understanding the prehistory of the region is made.

Response

The questions relating to regional resource significance and the cumulative effects of existing, approved and planned developments in the region are complex and may not be approachable in quantitative terms. Shell will contact Parks Canada to further discuss their comments and to obtain their input. Shell will include appropriate recommendations in the Historical Resource Management Plan that will be submitted for the project.

Question No. 2

Shell No. PC 2

Issue **Cultural Resource Impact Review**

Request

However, given the nature of nomadic hunting-gathering societies, the groups primarily reflected in the archaeological record of the study area, a single site which appears insignificant with regard to the quantity and type of cultural remains identified, may reflect one specific aspect of a seasonal round of subsistence. As a result the loss of a number of sites reflecting a singular aspect of an ongoing seasonal pattern of subsistence may result in a very significant loss of cultural resource information within the region. Sites which reflect only single episodes of activity are often easier to interpret because there are not the complexities of sorting through collapsed or mixed stratigraphic contexts. A program of major sample recoveries from a series of these smaller sites may be as important as recoveries from one major "significant" site. It is therefore important that within the determination of the degree of loss that single activity sites of a specific function be evaluated as a single component of regional land-use. When making this determination other site losses, not directly related to this project, should also be taken into account due to previous impacts which would include other oil sands related work. Some of these impacts have been identified in the report (Page D13-4) and would include:

a) cuts along the Athabasca and Muskeg rivers and Jackpine Creek;
b) disturbances created by the Fort Chipewyan winter road;
c) disturbances from the lease road and other transportation corridor developments; and
d) clearing for an airstrip, a plant and the various exploration programs.

By generally viewing the sites individually and not specifically as a cluster of regional activities, the study's ability to conduct a cumulative effects analysis has been limited. The overall effects are even greater when the loss of cultural resources from previous activities and processes are combined with the present project proposal.

This problem is in evidence when the cumulative effects are discussed in section F13 of the study. In this section it is stated that a " historical resources CEA (Cumulative Effects Analysis) is not considered applicable for this EIA (Environmental Impact Assessment)". This may be more a result of the study being oriented away from one that can easily address the cumulative impacts to the archaeological record and how it affects our geographical understanding of each cultural group. This occurs by not accounting for a particular part of the seasonal round of a nomadic/hunter gather group and whether that aspect is obliterated. In other words, just because the individual sites themselves do not meet the criteria of a high or moderate magnitude of significance does not mean that a group of sites representing certain functions which are lost may not be significant. If this study is to include a cumulative effects analysis of cultural resources there needs to be a careful identification of site functions and assurance that a representative sample of the archaeological record is left intact within the regional context. In addition there needs to be an evaluation of whether the loss of a large number of sites in an area identified as the densest known site area in Alberta's forested region is in itself significant.

Response See the response to PC 1.

Question No. **3**

Shell No. **PC 3**

Issue **Cultural Resource Impact Review**

Request One additional aspect of the cumulative assessment for historic resources should also include the fact that this project will result in a reduced water flow for the Athabasca River. This river has served as a major transportation corridor in the past and a number of historic and archaeological have been previously recorded along this waterway. As a result any reduction in the flow of the river could result in the exposure of archaeological and historic resources which were previously inundated.

In summary the overall assessment of the cultural resources in the study area is very thorough, but the cumulative impacts from this project and other related oil sands developments although partially addressed by the nature of the mitigation measures has not fully considered the impact on the regional archaeological record. Efforts to increase the sample recoveries of some of the single activity sites and an explanation as to how this would preserve in more detail the archaeological record of the region would significantly address these issues.

Response The flow of the Athabasca River during extreme low flow conditions, i.e., 7Q10, will be reduced 2% by the Muskeg River Mine Project and 6.4% by the RDR scenario.

The effects of reduced flows on the exposure of historic and archaeological sites are not clear. Reduced flows may have little effect on the normal variation expected in water levels. Lower flows may reduce erosion and therefore decrease the rate of site exposure that would be expected under natural flow regimes.

It is assumed that the main concern is for fur trade era and later remains since, given the river's activity within its flood plain, modern flood plain terraces are probably recent phenomena in archaeological terms and have little potential for prehistoric archaeological sites. Despite several river bank surveys few sites have been recorded along the river banks. Fur trade post sites would have been placed well above the anticipated spring flood zone, although dumps associated with these sites may have extended to the current river level.

Question No.	**4**
Shell No.	**PC 4**
Issue	**Surface Water Impact Review**

Request

The water requirements for the Muskeg River Mine Project are discussed in Volume 1, section 8.3. Shell Canada is requesting approval for the withdrawal of water from the Athabasca River at a design rate of 80 million m^3/a. The water withdrawal rate will be at maximum for two years of operation, and falling off to 17% of maximum in year 3. For the next 10 years, withdrawal rates will be at 50% of maximum.

Although the regional study area for the purpose of evaluating potential surface water quality was extended to include the Athabasca River to its confluence with the Embarras River, Parks Canada is of the opinion that the cumulative effects assessment of reduced flows in the Athabasca River should have extended to include the Peace-Athabasca Delta. Over the past twenty years, the landscape of the Peace-Athabasca Delta has experienced a major drying trend. The lack of flooding, particularly in the elevated lakes, or perched basins, has had a profound effect on the natural environment and on traditional lifestyles. Although the Northern Rivers Basin Study (1996) recognized that good planning and management will allow sustainable development along the northern rivers (Peace, Athabasca and Slave rivers), the governments of Alberta, N.W.T. and Canada are committed to the scientifically-based ecological management of the Peace-Athabasca Delta. The government response to the Northern Rivers Basin Study also acknowledges that long-term protection of the northern rivers depends on the watershed-management of <u>all</u> practices that affect both water quantity and quality.

Since the Muskeg River Mine project will impact on the Athabasca River as outlined in Volume 4, F4-17, and result in reduced flows, how will this reduction impact on the greater ecosystem, which includes the Peace-Athabasca Delta and the flooding regime which is essential to ecosystem health?

Response

The reduced flows in the Athabasca River as a result of the Muskeg River Mine Project represent 2% of extreme low flows, i.e., 7Q10, and should not impact the Peace-Athabasca Delta. See also the response to DFO 3.

Question No.	**5**
Shell No.	**PC 5**
Issue	**Surface Water Impact Review**

Request

If information is unavailable to reach a conclusion about the impacts to the Delta as a result of reduced flows, is Shell Canada prepared to undertake studies to better understand the dynamics between the reduced flows on the Athabasca River and possible changes to the flooding regime in the Delta, consistent with the governments' commitments?

Response

No. However, Shell will raise the issue to the Regional Aquatic Monitoring Program Steering Committee.

Question No. 6

Shell No. PC 6

Issue **Surface Water Impact Review**

Request

One of the main objectives of the Northern Rivers Basin Study was to define the combined effect of multiple developments on the Peace, Athabasca and Slave river ecosystems. Environmental stressors were measured in a number of ways by researchers to determine their effect on aquatic life. Although it was found that many reaches of the Peace, Athabasca and Slave rivers appear minimally affected by environmental stress, in other reaches, fish and other aquatic organisms are experiencing stress. While the studies couldn't clearly measure the nature and extent of these problems, the results raise significant concern that cumulative environmental stress may be affecting the health of aquatic life within certain river reaches. The Northern Rivers Basin Studies Board concluded that this issue warranted further attention to ensure that present and future developments do not impair the ecological well being of the rivers and recommended further study.

The cumulative effects assessment of surface water quality in Volume 4, F5, indicates that the combined developments will result in exceedances for certain parameters. Will Shell Canada participate in regional aquatic studies to confirm that the exceedances in the Athabasca and Muskeg rivers do not result in downstream impacts within the Peace-Athabasca Delta to wildlife and human health?

Response

Shell is a contributing member of the Regional Aquatic Monitoring Program (RAMP) for the oil sands area. One of the objectives of the RAMP is to monitor aquatic environments to allow the assessment of cumulative effects and regional trends over time.

AEP 1994. *Natural Regions and Subregions of Alberta.* Edmonton, Alberta, 13 p.

AEP. 1992. *Fisheries Habitat Protection Guidelines, Guideline 6: Timing Constraints on Construction In and Around Watercourses.* Fish and Wildlife Division.

AEP. 1993. *Alberta Ambient Surface Water Quality Interim Guidelines.*

AEP. 1995. *Water Quality Based Effluent Limits Procedures Manual.* Environmental Regulatory Seminar, Edmonton, Alberta.

AEP. 1996. *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan.*

AEP. 1996. *Protocol to Develop Alberta Water Quality Guidelines for Protection of Freshwater Aquatic Life.* Environmental Assessment Division, Environmental Regulatory Service, Edmonton, Alberta. 61 p.

Akena, A.M. 1979. *An Intensive Surface Water Quality Study of the Muskeg River Watershed. Volume 1: Water Chemistry.* Prepared for the Alberta Oil Sands Environmental Research Program by Alberta Environment. AOSERP Report 85. 187 p.

Alberta Transportation and Utilities. 1994. *Guidelines for Bridge Structure Standards Approval and Design.*

Allan, R., and T. Jackson. 1978. *Heavy Metals in Bottom Sediments of the Mainstream Athabasca River System in the AOSERP Study Area.* Prepared for the Alberta Oil Sands Environmental Research Program. AOSERP Report 34. 72 p.

Alsands Project Group, 1978. *Environmental Impact Assessment.* Presented to Alberta Environment in Support of an Oil Sands Mining Project.

Angle, R.P. and H.S. Sandhu. 1986. *Rural Ozone Concentrations in Alberta, Canada.* Atmospheric Environment, 20. p. 1221-1228.

Angle, R.P. and H.S. Sandhu. 1989. *Urban and Rural Ozone Concentrations in Alberta, Canada.* Atmospheric Environment, 23. p. 215-221.

B.C. Environment. 1997. *Contaminated Sites Regulation.*

Balcom R. J. 1996. *Historical Resources Impact Assessment.* Suncor Inc. Steepbank Mine (permit 95-83). On file Archaeological Survey Provincial Museum of Alberta, Edmonton.

Bond, W.A. 1980. *Fishery Resources of the Athabasca River Downstream of Fort McMurray: Volume 1.* Prepared for the Alberta Oil Sands Environmental Research Program by the Department of Fisheries and Oceans, Fisheries and Marine Service. AOSERP Report 89. 81 p.

Bond, W.A., and K. Machniak. 1977. *Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta.* Prepared for the Alberta Oil Sands Environmental Research Program by the Department of Fisheries, Fisheries and Marine Service. AOSERP Report 26. 137 p.

Bond, W.A., and K. Machniak. 1979. *An intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta.* Prepared for the Alberta Oil Sands Environmental Research Program by Environment Canada, Freshwater Institute. AOSERP Report 76. 180 p.

BOVAR Environmental Ltd. 1996. *Environmental Impact Assessment for the Syncrude Canada Limited Aurora Mine*. Appendix D, p. D-12.

Bower, J.S., K.J. Stevenson, G.F.J. Broughton, J.E. Lampert, B.P. Sweeney and J. Wilken. 1994. *Assessing Recent Surface Ozone Concentrations in the U.K.* Atmospheric Environment 28. p. 53-69.

Cadman, M.D. and A.M. Page. 1990. *Status report on the short-eared owl Asio Flammeus in Canada*. COSEWIC, Ottawa.

Canadian Council of Ministers of the Environment (CCME). 1990. *Management Plan for Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOCs), Phase I. Summary Report.* CCME-EPG/TRE-32E.

Canadian Council of Ministers of the Environment (CCME). 1997. *Recommended Canadian Soil Quality Guidelines.*

Canadian Council of Ministers of the Environment (CCME). *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Above Ground Storage Tanks.* CCME-EPC-87E.

Canadian Council of Ministers of the Environment (CCME). *Management Plan.*

Canadian Standards Association. *Design of Highway Bridges*. CAN/CSA-S6-88.

Carey, J.H., E.D. Ongley and E. Nagy. 1990. *Hydrocarbon Transport in the Mackenzie River, Canada.* Sci. Total Environ. 97/98. p. 69-88.

Conaty, G. 1979. *Alsands Lease Archaeological Survey.* Consultant's report (permit 79-56). On file, Archaeological Survey, Provincial Museum of Alberta, Edmonton.

Concord Environmental Corporation 1993. *An Assessment of Oil Sands Plant Contribution to Ground-Level Ozone Concentrations in the Fort McMurray Area (Draft)*. Prepared for Syncrude Canada Limited.

Crosley, R.W. 1996. *Environmental Contaminants in Bottom Sediments, Peace and Athabasca River Basins, October, 1994 and May, 1995.* NRBS Report 106. Northern River Basins Study, Edmonton, Alberta. 46 p. + App.

Davies, T.D. and E. Schuepback. 1994. *Episodes of High Ozone Concentrations at the Earth's Surface Resulting from Transport Down from the Upper Troposphere/Lower Stratosphere: A Review and Case Studies.* Atmospheric Environment 28. p. 53-68.

Donald, D.B. et al. 1996. *NRBS Indicators of Ecosystem Integrity: Peace-Athabasca Delta.*

Environment Canada. 1996. *Guidance Document on the Interpretation and Application of Data for Environmental Toxicology.* Environmental Protection, Conservation and Protection. Ottawa, Ontario.

Environmental Protection and Enhancement Act, *Approvals Procedure Regulation.*

EVS. 1995. *Biological Treatment Options for Consolidated Tailings Release Waters.* Prepared for Suncor Inc., Oil Sands Group.

EVS. 1996. *Constructed Wetlands for the Treatment of Oil Sands Wastewater.* Technical Report 5. Prepared for Suncor Inc., Oil Sands Group.

Ford et al. 1995. *Literature Reviews of the Life History, Habitat Requirements and Mitigation/Compensation Strategies for Thirteen Sport Fish Species in the Peace, Liard and Columbia River Drainages of British Columbia.* Canadian Manuscript Report of Fisheries and Aquatic Sciences 2321.)

Fort McKay Environmental Services. 1991. *Fort McKay Position Paper on the Environmental Effects of the Proposed OSLO Project.* 43 p. + App.

Fox, J.C. 1980. *Sand and Gravel Resources of the Athabasca Oil Sands Region, Northeastern Alberta.* Open File Report No. 1980-7. Alberta Energy and Utilities Board and Alberta Geological Survey.

FTFC (Fine Tailings Fundamentals Consortium), 1995. *In: Advances in Oil Sands Tailings Research*, Alberta Department of Energy, Oil Sands and Research Division.

Golder Associates Limited and Conor Pacific Environmental Technologies Inc. 1998. *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region.* Prepared for Suncor Energy Inc., Oil Sands Project Millennium.

Golder Associates Limited. 1995. *The Effect of Littoral Zone Area on Lake Productivity.* Prepared for Syncrude Canada Limited.

Golder Associates Limited. 1996. *Aquatic Baseline Report for the Athabasca, Steepbank and Muskeg Rivers in the Vicinity of the Steepbank and Aurora Mines.* 164 p. + App.

Golder Associates Limited. 1996. *Athabasca River Water Releases Impact Assessment.* Report for Suncor Energy Inc.

Golder Associates Limited. 1997. *Addendum to Syncrude Aurora Mine Environmental Baseline Program: Autumn 1996 Fisheries Investigations.* Draft report for Syncrude Canada Limited.

Golder Associates Limited. 1997. *Aquatic Resources Baseline Study for the Muskeg River Mine Project.* Prepared for Shell Canada Limited. 90 p. + App.

Golder Associates Limited. 1997. *Field-Scale Trials to Assess Effects of Consolidated Tails Release Water on Plants and Wetlands Ecology.* Prepared for Suncor Inc.

Golder Associates Limited. 1998. 1997 Synthesis of Environmental Information on Consolidated/Composite Tails (CT). Report for Suncor Energy Inc., Oil Sands Group, Fort McMurray, Alberta.

Golder Associates Limited. 1998. *Environmental Impact Assessment for the Muskeg River Mine Project.* 4 Volumes. Prepared for Shell Canada Limited.

Golder Associates Limited. 1998. *Oil Sands Regional Aquatics Monitoring Program (RAMP) 1997.* Prepared for Syncrude Canada Limited, Suncor Energy Inc. and Shell Canada Limited.

Goudey, J.S., H.R. Hamilton, and B.R. Taylor. 1990. *Receiving Water Assessment for the Disposal of Treated Basal Aquifer Water and Secondary Swage to Kearl Lake.* HydroQual Canada Ltd. 85 p. + App.

Griffiths, W.H. and B.D. Walton. 1978. *The Effects of Sedimentation on the Aquatic Biota.* Prepared for the Alberta Oil Sands Environmental Research Program by Renewable Resources Consultants Ltd. AOSERP Report 35. 86 p.

Halsey, L. and D.H. Vitt. 1996. *Alberta Wetland Inventory Standards – Version 1.0. In: Nesby, R. (ed). Alberta Vegetation Inventory Standards Manual. 1997.* Alberta Environmental Protection Resource Data Division.

Hamilton, H.R., B.R. Taylor and G. Macdonald. 1990. *Water Quality Evaluation of the Proposed OSLO Effluent Discharge to the Athabasca River.* HydroQual Canada Ltd. 78 p. + App.

Hammer, U.T., R.C. Haynes, J.M. Hesseltine and S.M. Swanson. 1975. *The Saline Lakes of Saskatchewan*. Verh. Internat. Verein. Limnol 19. p. 589-598.

Hartland-Rowe, R.C.B., R.W. Davies, M. McElhone, and R. Crowther. 1979. *The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta.* Prepared for the Alberta Oil Sands Environmental Research Program by the Department of Biology, University of Calgary. AOSERP Report 49. 144 p.

Harvey, C.A. 1998. *Basic Evaporative Emission Rates for Nonroad Engine Modeling*. Report No. NR-012. US EPA, Office of Mobile Sources.

Hesslein, R.H., 1977. *Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area.* Prepared for the Alberta Oil Sands Environmental Research Program by the Freshwater Institute, Environment Canada. AOSERP Report 71. 36 p.

HWC. 1995. *Guidelines for Canadian Drinking Water Quality*. Supporting Documentation.

HydroQual Laboratories Ltd. 1996a. *Laboratory Studies on Trophic Level Effects and Fish Health Effects of Suncor Tar Island Dyke Wastewater.* Report for Suncor Inc., Oil Sands Group, Calgary, Alberta.

HydroQual Laboratories Ltd. 1996b. *Laboratory Tests of Trophic Level Effects and Fish Health Effects and Tainting Potential of Suncor Refinery Effluent.* Report for Suncor Inc., Oil Sands Group, Athabasca River Water Releases Impact Assessment. Calgary, Alberta.

Ives, J. W. 1982a. *Evaluating the Effectiveness of Site Discovery Techniques in Boreal Forest Environments*. In Peter D. Francis and Eric C. Poplin, eds., Directions in Archaeology: A Question of Goals. p. 95-114, Calgary Archaeological Association, University of Calgary.

Ives, J. W. 1988. *Site Positioning Strategies in the Boreal Forest — Why the Alsands Sites Were Where They Were.* Paper presented to the Canadian Archaeological Association Meetings, May 13, Whistler B.C., 1988.

Jacobs, F.S.U. 1982. The Nature and Significance of Trace Elements in Oil Sands and Heavy Oils. Washington State University, Department of Chemistry.

Jones, M.L., G.J. Mann, and P.J. McCart. 1978. *Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray:* Volume 1. Prepared for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 36. 71 p.

Khalil, M.A.K and R.A. Rasmussen. 1990. *Atmospheric Methane: Recent Global Trends.* Environmental Science and Technology. Volume 24, No. 4. 549 p.

Lake, W. and W. Rogers. 1979. *Acute Lethality of Mine Depressurization Water to Trout-Perch (Percopsis omiscomaycus) and Rainbow Trout (Salmo gairdneri).* Volume 1. Prepared for the Alberta Oil Sands Environmental Research Program and Alberta Environment, Water Quality Control Branch. AOSERP Report 23. 44 p.

Lands and Forests. 1996. *Recommended Native Grasses and Legumes for Reclamation in the Green Area.*

Laurila, T. and H. Lattila. 1994. *Surface Ozone Exposures Measured in Finland.* Atmospheric Environment 28. p 53-68.

Legge, A.H. and S.V. Krupa. 1990. *Acidic Deposition: Sulphur and Nitrogen Oxides.* Lewis Publishers Inc.

Lock, M.A., and R.R. Wallace. 1979. *Aquatic Biological Investigations of the Muskeg River Watershed.* Prepared for the Alberta Oil Sands Environmental Research Program by Freshwater Institute, Environment Canada. AOSERP Report 67. 29 p.

Lockhart, W. L., D.A. Metner. 1996. *Analysis of Liver mixed-Function Oxygenase in Fish, Peace, Athabasca and Slave River Basins, September to December, 1994.* Northern River Basins Study Project Report No. 132. 53 p.

MacFarlane, I.C. 1969. *Muskeg Engineering Handbook.* Canadian Building Series, University of Toronto Press, Toronto.

Machniak K. 1976. *The Impact of Saline Waters Upon Freshwater Biota (A Literature Review and Bibliography).* Prepared for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 8. 258 p.

Malhotra, S.S. and A.A. Khan. 1984. *Biochemical and Physiological Impact of Major Pollutants. In: Treshow, A. (ed.). Air Pollution and Plant Life.* John Wiley & Sons, New York. p.113-157.

McCullough, E. J. 1989. *Historical Resource Phase 1: Baseline Study OSLO Project* (permit 89-52). On file, Archaeological Survey, Provincial Museum of Alberta, Edmonton.

McCullough, E. J. and C. Fowler. 1982. *Esso Resources Canada Ltd. Bituminous Sand Leases 29, 31, 32 and 78. Post Clearance Survey: An experimental Approach* (permit 82-42). On file, Archaeological Survey, Provincial Museum of Alberta, Edmonton.

NRCB. 1992. *Application to Construct a Recreational and Tourism Project in the Town of Canmore, Alberta.* Decision Report Application 9103 - Three Sisters Golf Resorts Inc.

Oil Sands Vegetation Reclamation Committee. 1998. *Guideline for Reclamation to Forest Vegetation in the Alberta Oilsands Region*. Draft Report. 58 p. +App.

Oil Sands Vegetation Reclamation Committee. 1998. *Guidelines for Reclamation to Terrestrial Vegetation in the Alberta Oil Sands Region.* Calgary, Alberta. 58 p. +App.

Organic Materials as Soil Amendments in Reclamation: A Review of the Literature. 1993. Report RRTAC 93-4, Alberta Conservation and Reclamation Council, Reclamation Research Technical Advisory Committee, Alberta Environmental Protection, Edmonton. 228 p.

Ozoray et al. 1980. ARC, *Earth Sciences Report* 78-6.

Pederson, U. and A.S. Lefohn. 1994. *Characterizing Surface Ozone Concentrations in Norway.* Atmospheric Environment 28. p. 53-68.

Prepas E.E. and D.O.Trew. 1983. *Evaluation of the Phosphorus-Chlorophyll Relationship for Lakes Off the Precambrian Shield in Western Canada*. Can. J. Fish Aquat. Sci. 40:27-35.

R. L. & L. Environmental Services Ltd. 1989. *OSLO Project – Water Quality and Fisheries Resource Baseline Studies.* 127 p. + App.

R. Webb Environmental Services Ltd. 1980. *Lake and Pond Fisheries Survey – Alsands Project Area.* 33 p.

R.A. Bothe, C. Abraham. 1987. *Evaporation and Evapotranspiration in Alberta 1912 to 1985.* Hydrology Branch, Technical Services Division, Water Resources Management Services, Alberta Environment.

Reeves, B. O. K. 1995. *Aurora Mine Project Historical Resources Overview & Baseline Study.* On file Archaeological Survey, Provincial Museum of Alberta.

Renault, S. and J.J. Zwiazek. 1997. *Phytotoxicity of Reclaimed Fine Tails and Tailing Sands*. Prepared for Suncor Inc., Oil Sands Group and Syncrude Canada Limited.

Roberts, T.L., and H. Regier. 1989. *Long Term Soil Acidification Monitoring in Alberta from 1981 to 1988*. Soil Protection Branch, Waste and Chemicals Division, Alberta Environment, Lethbridge, Alberta. Unpublished Report.

Ronaghan B. M. 1981a. *Historical Resources Impact Assessment Fort McMurray Energy Corridor, Fort Hill Townsite and Airstrip* (permit 80-91). On file, Archaeological Survey, Provincial Museum of Alberta, Edmonton.

Ronaghan B. M. 1981b. *Historical Resources Impact Assessment of Selected Portions of the Alsands Lease 13* (permit 80-91). On file, Archaeological Survey, Provincial Museum of Alberta, Edmonton.

Ronaghan B. M. 1982. *Controlled Surface Collection of the Cree Burn Lake Site (HhOv 16). Highway 963*. (ASA permit 81-153c). On file, Archaeological Survey of Alberta, Edmonton.

Saffran and Trew. 1996. *Sensitivity of Alberta Lakes to Acidifying Deposition: An Update of Sensitivity Maps with Emphasis on 109 Northern Lakes*. Water Sciences Branch, Water Management Division, Alberta Environmental Protection.

Schwartz, F.W. 1980. *Hydrogeological Investigation of Muskeg River Basin, Alberta*. Department of Geology. AOSERP Report 87. 97 p.

Sekerak, A.D. and G.L. Walder. 1980. *Aquatic Biophysical Inventory of Manor Tributaries in the AOSERP Study Area. Volume 1: Summary Report*. Prepared for the Alberta Oil Sands Environmental Research Program by LGL Limited, Environmental Research Associates. AOSERP Report 114. 100 p.

Shell Canada Limited, 1975. *Environmental Impact Assessment – Lease 13 Mining Project Alberta Oil Sands*.

Shell Canada Limited. 1998. *Application for Approval of the Muskeg River Mine Project*, Volume 1.

Sims, C, and T. Losey. 1975. *Archaeological Investigations in Athabasca Tar Sands Lease 13. A Sample Survey* (permit 74-31). On file, Archaeological Survey, Provincial Museum of Alberta, Edmonton.

Smith, S.L., D.D. MacDonald, K.A. Keenlyside and C.L. Gaudet. 1996. *The Development and Implementation of Canadian Sediment Quality Guidelines. In: Munawar, M. and G. Dave (editors). 1996. Development and Progress in Sediment Quality Assessment: Rationale, Challenges, Techniques and Strategies*. Ecovision World Monograph Series. SPB Academic Publishing, Amsterdam, The Netherlands. p. 233-249.

Suncor Inc., Oil Sands Group. 1996. *Steepbank Mine Project Application.*

Thomas, J.W. (ed.). 1979. *Wildlife Habitats in Managed Forest: the Blue Mountains of Oregon and Washington.* US Department. of Agriculture. Agriculture Handbook No. 553. 512 p.

Tripp, D.B. and P.J. McCart. 1979. *Investigations of the Spring and Spawning Fish Populations in the Athabasca and Clearwater Rivers Upstream from Fort McMurray*: Volume 1. Prepared for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 84. 128 p.

Tsuii, P.T.P., B.R. McMahon, P.J. McCart and J.V. McCart. 1980. *A Laboratory Study of Long-Term Effects of Mine Depressurization Groundwater on Fish and Invertebrates.* Prepared for the Alberta Oil Sands Environmental Research program by Aquatic Environments Ltd. AOSERP Report 113. 211 p.

UMA Engineering. 1991. *Environmental Impact Assessment Report for the Three Sisters Golf Resorts Inc. Destination Resort, Canmore, Alberta*. Vol. II.

US EPA. 1991. *Technical Support Document for Water Quality-Based Toxics Control.* Office of Water Regulations and Standards, Washington, D.C. EPA/505/2-90-001.

Van Dyke, S. G. 1980. *Final Report Historical Resources Impact Assessment Athabasca Oil Sands Region. West Ft. McMurray*. (permit 80-170). On file, Archaeological Survey, Provincial Museum of Alberta.

Walters, Thomas F. 1995. *Sediment in Streams: Sources, Biological Effects, and Control*. American Fisheries Society, Monograph 7.

Ward, J.V. and J.A. Stanford, 1979. *Ecological Factors Controlling Stream Zoobenthos with emphasis on Thermal Modification of Regulated Streams, in The Ecology of Regulated Streams*. Plenum Press, New York. 398 p.

W-E-R Engineering Ltd. 1989. *Environmental Evaluation of Alternative Headwater Diversions – for the OSLO Project*. 109 p. + App.

Wiederholm, T. 1984. *Responses of Aquatic Insects to Environmental Pollution.* In V.H. Resh and D.M. Rosenberg (eds), 1984. The Ecology of Aquatic Insects. Praeger Publishers, New York, N.Y.

Xu, J.G. and R.L. Johnson. 1996. *Plant Growth, Dewatering and Contaminant Uptake from Oil Sands Fine Tails and Tailings.* Alberta Environmental Centre, Vegreville, Alberta. Prepared for Suncor Inc., Oil Sands Group.

μ	The metric symbol for micron.
7-Q-10 Discharge	The minimum average discharge over a period of seven days duration which has a return period of 10 years; i.e., the probability that the minimum seven-day duration discharge will be equal to or less than the stated value is 10%.
a	The metric symbol for year.
acidification	The addition of acid to a solution until the pH falls below 7.
activity area	A limited portion of a site in which a specialized cultural function was carried out, such as hide scraping, tool manufacture, food preparation and other activities.
additive	A substance added to another substance in small amounts.
adsorption	The surface retention of solid, liquid or gas particles by a solid or liquid.
adverse effect	An undesirable effect to an organism (human, animal or plant), indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations or visible pathological changes.
AEP	The abbreviation for Alberta Environmental Protection.
agglomeration	A technique that combines small particles to form larger particles.
agitation tank	A vessel in which slurry material is maintained in suspension by using an impeller or by recirculating the material with pumps.
Ah horizon	An A horizon of organic matter accumulation containing less than 17 percent carbon.
airshed	The geographic area requiring unified management for achieving air pollution control.

alkalinity A measure of water's capacity to neutralize an acid. It indicates the presence of carbonates, bicarbonates and hydroxides, and less significantly, borates, silicates, phosphates and organic substances. It is expressed as an equivalent of calcium carbonate. The composition of alkalinity is affected by pH, mineral composition, temperature and ionic strength. However, alkalinity is normally interpreted as a function of carbonates, bicarbonates and hydroxides. The sum of these three components is called total alkalinity.

ambient air The air in the surrounding atmosphere.

ambient noise The pre-existing sound environment of a location, before the introduction of, or in absence of, noise from a specific source which also affects the sound environment of that location.

antiscalant An additive which prevents the buildup of scale, such as from calcium or iron.

AOSCEHEAP The abbreviation for Alberta Oil Sands Community Exposure Health Effects Assessment Program.

AOSTRA The abbreviation for Alberta Oil Sands Technology Research Authority.

API The abbreviation for the American Petroleum Institute.

aqueous mixture A combination of substances, one of which is water.

aquifer A water-saturated, permeable body of rock capable of transmitting significant or usable quantities of groundwater to wells and springs under ordinary hydraulic gradients.

aquifer depressurization The process of reducing the natural hydrostatic pressure in an aquifer.

aquitard A bed of low permeability adjacent to an aquifer, which might serve as a storage unit for groundwater, although it does not yield water readily.

asphaltene Any of the dark, solid constituents of crude oil or bitumen that are soluble in carbon disulphide but insoluble in paraffin naphthas. They hold most of the organic constituents of bitumen.

ASTM The abbreviation for the American Society for Testing Materials.

ATC The abbreviation for Athabasca Tribal Council.

attenuation A reduction in sound level that occurs with sound propagation over distance by means of physical dissipation or absorption mechanisms, or a reduction in sound level that occurs by means of noise control measures applied to a sound source.

Atterberg limits	A geometric and decimal grade scale for classifying particles in sediments based on the unit value of 2 mm and involving a fixed ratio of 10 for each successive grade. Subdivisions are geometric means of the limits of each grade.
ATV	The abbreviation for all-terrain vehicle.
AWI	The abbreviation for Alberta Wetlands Inventory.
bank cubic metre	A cubic metre of material in place.
baseline	A surveyed condition that serves as a reference point to which later surveys are coordinated or correlated.
basic sound level	The allowable sound level at a residential location, as defined by the current EUB Directive, with the inclusion of industrial presence based upon dwelling unit density and proximity to transportation noise sources.
BAW	The abbreviation for beach above water.
bbl	The abbreviation for barrel.
bbl/d	The abbreviation for barrels per day.
bbl/yr	The abbreviation for barrels per year.
BBW	The abbreviation for beach below water.
bcm	The abbreviation for bank cubic metres.
bedrock	The body of rock that underlies gravel, soil or other superficial material.
benthic invertebrates	Organisms that live at the bottom of lakes, ponds or streams.
berm	A mound or wall of earth.
BHP	The abbreviation for The Broken Hill Proprietary Company Limited.
bioaccumulation	The process of an organism storing in its body a higher concentration of a substance than is found in the environment.
bioavailability	The amount of a substance that enters the body following administration of, or exposure to, the substance.
biocide	A chemical agent that destroys pests. Also known as *pesticide*.
biodiversity	The variety of organisms and ecosystems within particular habitats.
biogenic	Essential to the maintenance of life.

biophysics	The application of physical principles and methods to study and explain the structures of living organisms.
bioremediation	The process of applying corrective action to unbalanced biological systems.
BIP	The abbreviation for bitumen in place.
bitumen	A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that might contain sulphur compounds and that, in its naturally occurring state, will not flow to a well.
bitumen froth	Air-entrained bitumen with a froth-like appearance that is the product of the primary extraction step in the warm or hot water extraction process.
bitumen grade	The amount of bitumen in oil sands, usually expressed as a percentage.
boiler feed water	Water that meets required purity specifications and is used in the heat recovery steam generator to produce steam.
borehole	The hole made by drilling or boring.
BS&W	The abbreviation for basic sediment and water.
BTU	The abbreviation for British thermal unit.
°C	The symbol for degrees Celsius.
$CaOH_2$	The chemical formula for calcium oxide.
C&R	The abbreviation for conservation and reclamation.
CANMET	The acronym for the Canadian Centre for Mineral and Energy Technology.
carcinogen	Any agent that incites development of a carcinoma or any other sort of malignancy.
CASA	The abbreviation for Clean Air Strategic Alliance.
CCME	The abbreviation for the Canadian Council of the Ministers of the Environment.
CEA	The abbreviation for cumulative effects assessment.
CEAA	The abbreviation for Canadian Environmental Assessment Agency.
centre reject material	Sand and clay material that is interbedded with the bitumen ore.
centrifuge	A rotating device for separating, by centrifugal force, suspended particles in solution, according to particle-size fractions.

CEPA	The abbreviation for the Canadian Environmental Protection Act.
CES	The abbreviation for cumulative effects study.
CH_4	The chemical formula for methane.
chronic toxicity	The development of adverse effects after an extended exposure to relatively small quantities of a chemical.
cm/a	The metric symbol for centimetres per year.
CML	The abbreviation for Consolidated Metis Locals.
CO_2	The chemical formula for carbon dioxide.
cofferdam	A temporary damlike structure constructed around an excavation to exclude water.
cogeneration	The simultaneous on-site generation of electrical power and process steam or heat from the same plant.
coke	A solid residue that contains mainly carbon produced from the (dry) distillation of petroleum or carbonaceous materials.
coker	The processing unit in which coking occurs.
commissioning	The act of setting up equipment and facilities for service.
compaction	The process of pore space reduction in soil or sediments from heavier overlying material weighing the soil down.
conceptual model	A model developed during early risk assessment that describes several working hypotheses.
condensate	A light hydrocarbon liquid obtained by condensing hydrocarbon vapours. Condensate typically contains mostly propane, butane and pentane.
conditioning tank	A vessel in which product is treated with additives to give it certain properties.
CONRAD	The acronym for Canadian Oilsands Network for Research and Development.
consolidated tailings	A non-segregating mixture of plant tailings that consolidates quickly in tailings deposits.
consolidation	The process by which a loose, soft or liquid substance becomes coherent and firm.

construction phase	The project stage involving building the plant and facilities and preparing for start-up.
contaminant	A substance added to a receiving environment in excess of natural concentrations.
contamination	The process of making unfit for use by introducing unwholesome or undesirable elements.
contouring	The process of shaping the land surface to fit the form of the surrounding land.
crude oil	Unrefined liquid petroleum.
crusher	A machine for crushing rock or other materials.
cryosolic soil	An order of mineral or organic soils proposed for adoption in the Canadian taxonomic system.
CT	The abbreviation for consolidated tailings.
cut-off grade	The grade value below which an ore cannot be extracted economically.
deaerator	A device in which oxygen, carbon dioxide, or other noncondensable gases are removed from boiler feedwater, steam condensate, or a process stream.
debottlenecking	The act of increasing the capacity of specific pieces of equipment, or parts of a process, to increase the capacity of the whole process.
decommissioning	The act of removing equipment and facilities from service.
deionization	An ion-exchange process in which all charged species or ionizable organic and inorganic salts are removed from solution.
density	The mass or weight of a substance per unit volume.
Devonian	The fourth period of the Paleozoic Era.
DFO	The abbreviation for the Department of Fisheries and Oceans.
DIAND	The abbreviation for the Department of Indian Affairs and Northern Development.
dilbit	A blend of diluent and bitumen.
diluent	The diluting agent added to bitumen to lower viscosity.
ditch	A long, narrow excavation dug in the earth for drainage.
DO	The abbreviation for dissolved oxygen.

dose	A measure of integral exposure. Examples include the amount of chemical ingested, the amount of a chemical taken up, and the product of ambient exposure concentration and duration of the exposure.
dyke	A bank of earth constructed to confine water.
ecosite	A subdivision of an ecosection, described and analyzed in detail.
ecosystem	An integrated and stable association of living and nonliving resources functioning within a defined physical location.
effluent	A stream of water discharging from a source.
EIA	The abbreviation for Environmental Impact Assessment.
ELC	The abbreviation for ecological land class.
emergency response	The action taken after an event to minimize the consequences of an emergency.
emissions	Substances discharged into the atmosphere through a stack. See also *stack emissions* and *fugitive emissions.*
emulsion	A stable dispersion of one liquid in a second liquid that will not mix with the first liquid.
endangered species	A species facing imminent extirpation or extinction in Canada..
end-pit lake	An artificial lake, used to fill the void at one end of a mine, into which the remaining fine tailings at the end of mine life are discharged and stored under a water cap.
environmental impact assessment	A review of the effects that a proposed development will have on the local and regional environment.
EPA	The abbreviation for Environmental Protection Agency.
EPC	The abbreviation for engineering, procurement and construction.
EPCM	The abbreviation for engineering, procurement and construction management.
EPEA	The abbreviation for Environmental Protection and Enhancement Act.
epilimnion	A freshwater zone of relatively warm water in which mixing occurs as a result of wind action and convection currents.
EPL	The abbreviation for end-pit lake.
ER	The abbreviation for exposure ratio.

erosion	The process by which material, such as rock or soil, is worn away or removed by wind or water.
ERT	The abbreviation for electrical resistivity tomography.
EUB	The abbreviation for Alberta Energy and Utilities Board.
exceedance	An emission whose measured value is more than that allowed by government regulations.
exposure	The contact between a chemical and a biological system or organism.
extirpation	The act of uprooting, destroying, making extinct or exterminating.
extraction	The process of separating bitumen from the oil sands.
facies	Part of a bed of sedimentary rock that differs significantly from the rest of the bed.
facilities	The surface equipment and pipelines required for mining and extraction operations.
fallback position	An alternative course of action.
FC	The abbreviation for Fluvial Channel Sand facies.
FEED	The abbreviation for front-end engineering and design.
feed ore	Bitumen ore that is processed in the extraction plant.
feedstock	Raw material supplied to a processing or refining facility.
fenceline approval	Approval for development activities within the boundaries of a lease area.
fens	Peat land covered by water, especially in the upper regions of old estuaries and around lakes, that can be drained only artificially.
FGD	The abbreviation for flue gas desulphurization.
fibrous	Capable of being separated into fibres.
fine tailings	A suspension of fine silts, clays residual bitumen and water produced during bitumen extraction from oil sands.
fines	Silt and clay particles.
flare stack	A chimney used to dispose of surplus hydrocarbon gases by igniting them in the atmosphere.

floating roof tank	A tank with a roof made of steel, plastic, sheet or microballoons, which floats upon the surface of the stored liquid. Floating roofs are used to decrease the vapour space and reduce the potential for evaporation.
flocculant	A reagent added to a dispersion of solids in a liquid to bring together the fine particles to form flocs.
flocs	Small masses formed in a fluid through coagulation, agglomeration or biochemical reaction of fine suspended particles.
flue gas desulphurization	A process involving the removal of a substantial portion of sulphur dioxide from the combustion gas (flue gas) formed from burning petroleum coke. Desulphurization is accomplished by contacting the combustion gases with a solution of limestone. Gypsum ($CaSO_4$) is formed as a byproduct of this process.
fluvial channel	A channel formed by a stream or river action.
fluvial deposits	All sediments, past and present, deposited by flowing water.
forecast	An estimate or prediction of future conditions.
formation	A geologic unit of distinct rock types that is large enough in scale to be mappable over a region.
FPOB	The abbreviation for Flood Plain and Overbank facies.
fresh water	Water that is not salty, especially when considered as a natural resource.
froth	A type of foam in which solid particles are also dispersed in the liquid, in addition to gas bubbles. The solid particles may be the stabilizing agent.
fugitive emissions	Trace amounts of uncombusted substances that are released into the atmosphere during normal facility and plant operations.
GJ	The metric symbol for gigajoules.
glacial till	Unsorted sedimentary material deposited directly by and underneath a glacier, consisting of a mixture of clay, silt, sand, gravel and boulders. Also known as *glacial deposits*.
glaciofluvial deposits	Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice.
gland	A device used to form a seal around a pump to prevent fluid leakage.
grade	A measure of the quality of raw ore, usually expressed as a percentage of the content of a particular component. See also *bitumen grade*.
grading	The process of leveling off to a smooth horizontal or sloping surface.

graminoid	Of or resembling grasses.
groundwater	Subsurface water that occurs beneath the water table in soils and geological formations that are fully saturated. It is the water within the earth that supplies water wells and springs.
grubbing	The process of clearing stumps and roots from land.
GSI	The abbreviation for gonadal somatic index.
gypsum	A mineral ($CaSO_4$ $2H_2O$).
ha	The abbreviation for hectare.
habitat	The part of the physical environment in which a plant or animal lives.
hazardous waste	Any waste material that presents a potential for unwanted consequences to people, property and the environment.
HHV	The abbreviation for higher heating value.
historical resources	Works of nature or by humans valued for their palaeontological, archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest.
historical resources impact assessment	A review of the effects that a proposed development will have on the local and regional historic and prehistoric heritage of an area.
HNO_3	The chemical formula for nitric acid.
HRIA	The abbreviation for historical resources impact assessment.
HSI	The abbreviation for wildlife habitat suitability indices.
Human Health Risk Assessment	The process of defining and quantifying risks and determining the acceptability of those risks to human life.
HV	The abbreviation for heating value.
hydraulic gradient	In an aquifer, the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.
hydrocarbons	One of a very large group of chemical compounds composed only of carbon and hydrogen; the largest source of hydrocarbons is from petroleum crude oil.
hydroconversion	The process of adding hydrogen to medium and heavy oils to produce light oil products.

hydrogeology	The study of the factors that deal with subsurface water (groundwater), and the related geological aspects of surface water.
hydrotransport	A method of transporting granular material, such as oil sands or extraction tailings, in a water-based slurry in a pipeline.
hypolimnion	The lower level of water in a stratified lake, characterized by a uniform temperature that is generally cooler than that of other strata in the lake.
impervious	Not allowing water or other fluid to pass through.
infrastructure	Basic facilities, such as transportation, communications, power supplies and buildings, which enable an organization, project or community to function.
interburden	Waste material located between economically recoverable oil sands.
Inversion	The process by which one type of emulsion is converted to another.
invertebrate	An animal without a backbone and internal skeleton.
IRC	The abbreviation for Industry Relations Corporation.
isopach map	A geological map of subsurface strata showing the various thicknesses of a given formation underlying an area.
isopleth	The straight line which cuts the three scales of a nomograph at values satisfying some equation.
karst	A topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.
keq	The metric symbol for killiequivalent.
keq/ha/a	The metric symbol for killiequivalent per hectare per year.
kg	The metric symbol for kilogram.
kg/d	The metric symbol for kilograms per day.
kg/h	The metric symbol for kilograms per hour.
kg/m	The metric symbol for kilograms per metre.
kg/s	The metric symbol for kilograms per second.
KIRs	The abbreviation for key indicator resources.
km	The metric symbol for kilometre.

km/h	The metric symbol for kilometres per hour.
kPa	The metric symbol for kilopascal.
kPa(g)	The metric symbol for kilopascal gauge.
kV	The metric symbol for kilovolt.
kW	The metric symbol for kilowatt.
L	The metric symbol for litre.
L/s	The metric abbreviation for litres per second.
leachate	A solution formed by leaching.
leaching	The process of dissolving soluble minerals or metals out of an ore.
LEE	The abbreviation for low energy extraction process.
LHV	The abbreviation for lower heating value.
lift	The horizontal surface, adjacent to the mine face, upon which mining equipment operates.
littoral zone	The biogeographic zone between the high and low-water marks.
LSA	The abbreviation for local study area.
M	The metric symbol for mega.
m	The metric symbol for metre.
m^2	The metric symbol for square metre.
m^3	The metric symbol for cubic metre.
m^3/a	The metric symbol for cubic metres per annum.
m^3/d	The metric symbol for cubic metres per day.
macronutrient	A large substance that provides nutrition.
makeup water	The process water required to replace that lost by evaporation or leakage in a closed-circuit, recycle operation.
masl	The abbreviation for metres above sea level.
material balance	A calculation to inventory material inputs versus outputs in a control system.

mature fine tailings	Fine tailings that have dewatered to about 30% solids during the three years following deposition.
Mbbl	The abbreviation for millions of barrels.
merchantable timber	The coniferous and deciduous trees that are cut down during site clearing and that can be sold.
MFT	The abbreviation for mature fine tailings.
mg	The chemical formula for magnesium.
mg/L	The metric symbol for milligrams per litre.
Microtox	A toxicity test that includes assaying light produced by a strain of luminescent bacteria.
min	The abbreviation for minute.
mitigate	To cause to become less harsh or hostile.
MLD	The abbreviation for McLelland (soil type).
mm	The metric symbol for millimetre.
modeling	A simplified representation of a relationship or system of relationships. Modeling involves calculation techniques used to make quantitative estimates of an output parameter based on its relationship to input parameters. The input parameters influence the value of the output parameters.
monitoring	The process of measuring continuously, or at intervals, a condition that must be kept within set limits.
MSL	The abbreviation for mineral surface lease.
MUS	The abbreviation for Muskeg (soil type).
Muskeg	A thick deposit of partially decayed vegetable matter of wet boreal regions.
MW	The metric symbol for megawatt.
naphtha	A petroleum fraction with volatility between gasoline and kerosene.
neutralization	The process of making a solution neutral (neither acidic nor basic, and with a pH of 7), by adding a base to an acidic solution or an acid to a basic solution.
NO_2	The chemical formula for nitrogen oxide.

NO_3	The chemical formula for nitric acid.
NOEC	The abbreviation for No Observable Effects Concentration. The highest concentration in a medium that does not cause a statistically significant difference in effect as compared to controls.
nomograph	A chart which represents an equation containing three variables by means of three scales, so that a straight line cuts the three scales in values of the three variables satisfying the equation.
nonpotable water	Water unfit for human consumption.
Non-toxic	Not poisonous.
NO_x	The chemical formula for oxides of nitrogen.
NPV	The abbreviation for net present value.
NQ	The abbreviation for not quantified.
NRB	The abbreviation for net recoverable bitumen.
NRBS	The abbreviation for the Northern River Basin Study.
Nutrients	Environmental substances, such as nitrogen or phosphorous, that are necessary for the growth and development of plants and animals.
NWPA	The abbreviation for Navigable Waters Protection Act.
O_3	The chemical formula for ozone.
OB	The abbreviation for overburden.
OBIP	The abbreviation for original bitumen in place.
OD	The abbreviation for outside diameter.
oil sands	An unconsolidated, porous sand formation or sandstone containing or impregnated with petroleum or hydrocarbons.
oligotrophic	Of a lake, lacking plant nutrients and usually containing plentiful amounts of dissolved oxygen without marked stratification.
operating costs	The dollar amount required to run a facility or organization.
operations phase	The project stage involving oil sands mining and bitumen extraction.
ore deposit	Rocks containing minerals of economic value in an amount that can be profitably exploited.

ore grade	A measure of the quality of raw ore, usually expressed as a percentage of bitumen content.
ore reserve	The total tonnage and average value of proved ore, plus the total tonnage and assumed value of the probable ore.
orebody	A solid and fairly continuous mass of ore, which may include low-grade ore and waste as well as pay ore, but is individualized by form or character from adjoining country rock.
organic matter	The fraction of a soil that contains plant and animal residues in various stages of decomposition.
OSEC	The abbreviation for Oil Sands Environmental Coalition.
overburden	All material, including soil, sand, silt or clay, that has to be removed to expose the ore before it can be mined.
PAH	The abbreviation for polycyclic aromatic hydrocarbon.
PAI	The abbreviation for potential acid input.
Paleosol	An ancient soil horizon.
paraffinic solvent	A solvent made up of a mixture of pentane and hexane.
particulate emissions	Emissions of fine particles of liquid or solid.
paste technology	A method of thickening fine clay particles by adding chemical polymers.
patch	A term used to recognize that most ecosystems are not homogeneous, but exist as a group of patches or ecological islands that are recognizably different from the parts of the ecosystem that surround them but nevertheless interact with them.
permeability	The capacity of a porous rock, soil, or sediment for transmitting a fluid without damaging the structure of the medium.
permissible sound level	The allowable overall A-weighted sound level of noise from energy industry sources, as specified by the EUB Noise Control Directive, which may contribute to the sound environment of a residential location.
pervious	A rock, soil or sediment that can transmit a fluid without structural alteration.
pH value	The measurement of a substance's acidity or alkalinity.
piezometer	An instrument for measuring fluid pressure.
PM	The abbreviation for particulate matter.

PMF	The abbreviation for probable maximum flood.
PMP	The abbreviation for probable maximum precipitation.
porewater	The fluid filling the small spaces between particles of rock.
potable water	Water that is suitable for drinking.
ppm	The abbreviation for parts per million.
precipitation	The rain or snow that falls on the earth's surface.
prestripping	The process of removing overburden from the surface of the land in preparation for mining.
procurement	The process of obtaining materials, equipment and services, including purchasing, contracting and negotiating directly with the source of supply.
production forecast	The amount of oil expected to be recovered within a particular time frame.
PSD	The abbreviation for paraffinic solvent demulsification.
QA	The abbreviation for quality assurance.
QC	The abbreviation for quality control.
Quaternary	The most recent geologic time period, encompassing the last two million years.
radiotelemetry	The process of obtaining data at a location remote from the source of the data, using radio waves for transmitting the data.
RAMP	The abbreviation for Regional Aquatics Monitoring Program.
RAQCC	The abbreviation for the Regional Air Quality Coordinating Committee.
RDR	The abbreviation for Regional Development Review.
reclaimed landscape	An area that has undergone reclamation.
reclamation	The process of stabilizing and returning disturbed land to a natural state of equivalent or better capability.
reclamation	The restoration of disturbed or waste land to a state of useful capability. Reclamation is the initiation of the process that leads to a sustainable landscape, including the construction of stable landforms, drainage systems, wetlands, soil reconstruction, addition of nutrients and revegetation. This provides the basis for natural succession to mature ecosystems suitable for a variety of end uses.

recycled water	Water that is stripped from the oil sands during the extraction process and treated for reuse in the process.
regenerant	A solution that restores the activity of an ion-exchange bed.
rejects	Material, such as clay or lean oil sands, that do not pass through the extraction sizing screens and are, therefore, excluded from the process.
reserves	The unproduced but recoverable bitumen in a formation that has been proven by production.
resin	A solid or semisolid organic product of natural or synthetic origin that has no definite melting point. Most resins are polymers.
resource	A natural source of revenue, such as oil or gas.
revegetation	The process of providing denuded land with a new cover of plants.
revetment	A facing made on a soil or rock embankment to prevent scour by weather of water.
riffle	Shallows across a stream bed over which water flows swiftly and is broken into waves by submerged obstructions.
right-of-way	The right of passage or of crossing over someone else's land. An easement in lands belonging to others that is obtained by agreement or lawful appropriation for public or private use.
riparian corridors	Corridors that are located on a riverbank.
riprap	A foundation or revetment in water or on soft ground made of irregularly placed stones or pieces of boulders; used chiefly for river and harbour work, for roadway filling, and on embankments.
RIWG	The abbreviation for the Regional Infrastructure Working Group.
RMS	The abbreviation for reclamation material storage.
RMWB	The abbreviation for Regional Municipality of Wood Buffalo.
rotary breaker	A rotating screen and lump breaker into which oil sands and hot water are added.
royalties	The share of profits reserved by the body granting an oil or mining lease.
RSA	The abbreviation for regional study area.
runoff	The portion of precipitation (rain and snow) that ultimately reaches streams via surface systems.

sandstone	A sedimentary rock composed of individual grains of sand cemented together.
sedimentary rock	A rock composed of materials that were transported to their present position by water or wind.
sedimentary sequence	The particular order in which rock layers occur.
sedimentary zone	A sedimentary rock stratum that is different from or distinguished from another stratum.
sedimentation pond	A small waterbody where suspended solid particles settle out and are deposited at the bottom of the pond.
seepage	The slow movement of water or other fluids through a porous medium, or through small openings in the surface of unsaturated soil.
SEIA	The abbreviation for socio-economic impact assessment.
sensible heat	The heat absorbed or evolved by a substance during a change of temperature that is not accompanied by a change of state.
separation	The process of isolating components in streams of mixed fluids.
separator	A vessel designed to separate the oil phase in a petroleum fluid from some or all of the other three constituent phases (gas, solids and water).
Shell	The abbreviation for Shell Canada Limited.
shutdown	The process of stopping equipment or machinery or a process, partly or completely.
site, historic	Any location with detectable evidence of past human activity.
slash	Debris, such as logs, chunks of wood, bark, and branches, in an open forest tract.
slash burning	The process of clearing vegetation from the land and setting fire to the remaining undergrowth.
slurry	A free-flowing, pumpable suspension of fine solid material in liquid.
SMART	The abbreviation for Shell McKay Application Review Team.
socio-economics	The study of social and economic factors.
soil capability	The measure of a soil's capacity to sustain vegetation.
SO_x	The chemical symbol for oxides of sulphur.

spudded	A hole that has been drilled.
SR	The abbreviation for strip ratio.
SRU	The abbreviation for solvent recovery unit.
stack	The portion of a chimney rising above the roof.
stack emissions	Substances discharged into the atmosphere through a plant stack.
stakeholder	People or organizations with an interest or share in an undertaking, such as a commercial venture.
start-up	The act of restarting work or energizing machinery or equipment after a temporary shutdown or commissioning.
start-up water	The additional volume of water required temporarily to start up a new development.
sterilization of ore	The process of making ore recovery uneconomical.
stockpile	A gradually accumulated reserve of material.
stratigraphy	A branch of geology that deals with the arrangement of rock layers.
Suncor	The abbreviation for Suncor Energy Inc.
surfactant	Any substance that lowers the surface or interfacial tension of the medium in which it is dissolved. Surfactants may be naturally occurring or a soluble chemical compound.
surficial aquifer	A surficial deposit containing water considered an aquifer.
surge	The accumulation of liquid above a normal or average level, or a sudden increase in its flow rate above a normal flow rate.
surge tank	A vessel through which liquids or gases are passed to ensure steady flow and eliminate pressure surges.
sustainability	The process of managing biological resources (e.g., timber, fish) to ensure replacement by regrowth or reproduction of the part harvested before another harvest occurs.
sustainable landscape	Landscape that can survive extreme events and natural cycles of change without being subjected to accelerated erosion or environmental impacts more severe than those of the natural environment.
Syncrude	The abbreviation for Syncrude Canada Limited.
synthetic crude oil	Oil obtained by refining heavier hydrocarbons.

t	The metric symbol for tonnes.
t/d	The metric symbol for tonnes per day.
t/h	The metric symbol for tonnes per hour.
tailings	A by-product of oil sands extraction comprising water, coarse sand, fine minerals and minor amounts of rejected bitumen waste.
tailings settling pond	An artificial impoundment structure to contain tailings. Tailings settling ponds are enclosed by dykes made with tailings and overburden materials to stringent geotechnical standards.
TEEM	The abbreviation for Terrestrial Environmental Effects Monitoring.
TERRE	The abbreviation for Terrestrial Reclamation on Challenging Material Research Program.
TFT	The abbreviation for thin fine tailings.
third-party services	Services contracted by one organization to another.
TID	The abbreviation for Tar Island Dyke.
timber salvage	The process of clearing the land of trees and retaining the trees to be sold for various uses.
topography	The configuration of a surface including its relief and natural and artificial features.
toxicity	The kind and amount of poison possessed by a chemical substance not of biological origin.
tremie	An apparatus for placing concrete underwater, consisting of a large metal tube with a hopper at the top end and a valve arrangement at the bottom, submerged end.
truck-and-shovel mining	The process of using large trucks and shovels to obtain ore from the ground.
TSRU	The abbreviation for tailings solvent recovery unit.
TSS	The abbreviation for total suspended solids.
TUa	The abbreviation for acute toxicity units.
turbine	A rotary engine, usually made with a series of curved vanes on a central spindle, that is actuated by a current of fluid, such as water, steam or air.
TV	The abbreviation for total volume.

TV/BIP	The abbreviation for the ratio of total volume to bitumen in place.
TV/NRB	The abbreviation for the ratio of total volume to net recoverable bitumen.
upgrader	A system of process units that uses either hydrogen addition or carbon rejection to convert bitumen or heavy oil to light oil products or light oil components.
US EPA	The abbreviation for the United States Environmental Protection Agency.
UTF	The abbreviation for underground test facility.
utilities	The supply of electricity, natural gas, water and sewer drains.
utility corridor	A right-of-way containing pipelines, power lines and road access.
UV	The abbreviation for ultraviolet.
vapour recovery	The process of capturing and recycling process water vapour in a closed-circuit system.
viscosity	The fluid property that characterizes the amount of functional energy loss during flow.
VOCs	The abbreviation for volatile organic compounds.
vol%	The abbreviation for volume percent.
VRU	The abbreviation for vapour recovery unit.
waste	All solids, liquids and sludge produced in the course of constructing, operating and abandoning the facilities.
waste management plan	The system developed to track and control emissions and waste and evaluate pollution-prevention steps.
water management plan	The system developed to optimize the use of available water supplies.
water table	The upper surface of groundwater or the level below which the soil is saturated with water. Also known as *phreatic surface.*
waterbody	A natural geographical feature containing water, such as a lake or stream.
watershed	An area bounded peripherally by a divide and draining ultimately to a particular watercourse or waterbody.
WBEA	The abbreviation for Wood Buffalo Environmental Association.
wellbore	The hole drilled by the bit in a well.

WET The abbreviation for whole effluent toxicity.

wetlands A broad group of wet habitats where the water table is usually at or near the surface or the land is covered by shallow water.

wt% The abbreviation for weight percent.

AEP. 1992. *Fisheries Habitat Protection Guidelines, Guideline 6: Timing Constraints on Construction In and Around Watercourses.* Fish and Wildlife Division.

AEP. 1993. *Alberta Ambient Surface Water Quality Interim Guidelines.*

AEP 1994. *Natural Regions and Subregions of Alberta.* Edmonton, Alberta, 13 p.

AEP. 1995. *Water Quality Based Effluent Limits Procedures Manual.* Environmental Regulatory Seminar, Edmonton, Alberta.

AEP. 1996. *Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan.*

AEP. 1996. *Protocol to Develop Alberta Water Quality Guidelines for Protection of Freshwater Aquatic Life.* Environmental Assessment Division, Environmental Regulatory Service, Edmonton, Alberta. 61 p.

Akena, A.M. 1979. *An Intensive Surface Water Quality Study of the Muskeg River Watershed. Volume 1: Water Chemistry.* Prepared for the Alberta Oil Sands Environmental Research Program by Alberta Environment. AOSERP Report 85. 187 p.

Alberta Transportation and Utilities. 1994. *Guidelines for Bridge Structure Standards Approval and Design.*

Allan, R., and T. Jackson. 1978. *Heavy Metals in Bottom Sediments of the Mainstream Athabasca River System in the AOSERP Study Area.* Prepared for the Alberta Oil Sands Environmental Research Program. AOSERP Report 34. 72 p.

Alsands Project Group, 1978. *Environmental Impact Assessment.* Presented to Alberta Environment in support of an Oil Sands Mining Project.

Angle, R.P. and H.S. Sandhu. 1986. *Rural Ozone Concentrations in Alberta, Canada.* Atmospheric Environment 20 p. 1221-1228.

Angle, R.P. and H.S. Sandhu. 1989. *Urban and Rural Ozone Concentrations in Alberta, Canada.* Atmospheric Environment 23 p. 215-221.

B.C. Environment. 1997. Contaminated Sites Regulation.

Bond, W.A. 1980. *Fishery Resources of the Athabasca River Downstream of Fort McMurray: Volume 1.* Prepared for the Alberta Oil Sands Environmental Research Program by the Department of Fisheries and Oceans, Fisheries and Marine Service. AOSERP Report 89. 81 p.

Bond, W.A., and K. Machniak. 1977. *Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta.* Prepared for the Alberta Oil Sands Environmental Research Program by the Department of Fisheries, Fisheries and Marine Service. AOSERP Report 26. 137 p.

Bond, W.A., and K. Machniak. 1979. *An intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta.* Prepared for the Alberta Oil Sands Environmental Research Program by Environment Canada, Freshwater Institute. AOSERP Report 76. 180 p.

BOVAR Environmental Ltd. 1996. *Environmental Impact Assessment for the Syncrude Canada Limited Aurora Mine*. Appendix D, p. D-12.

Bower, J.S., K.J. Stevenson, G.F.J. Broughton, J.E. Lampert, B.P. Sweeney and J. Wilken. 1994. *Assessing Recent Surface Ozone Concentrations in the U.K.* Atmospheric Environment 28. p. 53-69.

Canadian Standards Association CAN/CSA-S6-88. *Design of Highway Bridges*.

Canadian Council of Ministers of the Environment (CCME). 1990. *Management Plan for Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOCs), Phase I. Summary Report.* CCME-EPG/TRE-32E.

Canadian Council of Ministers of the Environment (CCME). 1997. *Recommended Canadian Soil Quality Guidelines*.

Canadian Council of Ministers of the Environment (CCME). *Management Plan.*

Canadian Council of Ministers of the Environment. *Environmental Guidelines for Controlling Emissions of Volatile Organic Compounds from Above Ground Storage Tanks*. CCME-EPC-87E.

Carey, J.H., E.D. Ongley and E. Nagy. 1990. *Hydrocarbon Transport in the Mackenzie River, Canada.* Sci. Total Environ. 97/98. p. 69-88.

Concord Environmental Corporation 1993. *An Assessment of Oil Sands Plant Contribution to Ground-Level Ozone Concentrations in the Fort McMurray Area (Draft)*. Prepared for Syncrude Canada Limited.

Crosley, R.W. 1996. *Environmental Contaminants in Bottom Sediments, Peace and Athabasca River Basins, October, 1994 and May, 1995*. NRBS Report 106. Northern River Basins Study, Edmonton, Alberta. 46 p. + App.

Davies, T.D. and E. Schuepback. 1994. *Episodes of High Ozone Concentrations at the Earth's Surface Resulting from Transport Down from the Upper Troposphere/Lower Stratosphere: A Review and Case Studies*. Atmospheric Environment 28. p. 53-68.

Donald, D.B. et al. 1996. *NRBS Indicators of Ecosystem Integrity: Peace-Athabasca Delta.*

Environment Canada. 1996. *Guidance Document on the Interpretation and Application of Data for Environmental Toxicology.* Environmental Protection, Conservation and Protection. Ottawa, Ontario.

Environmental Protection and Enhancement Act, *Approvals Procedure Regulation.*

EVS. 1995. *Biological Treatment Options for Consolidated Tailings Release Waters*. Prepared for Suncor Inc., Oil Sands Group.

EVS. 1996. *Constructed Wetlands for the Treatment of Oil Sands Wastewater.* Technical Report 5. Prepared for Suncor Inc., Oil Sands Group.

Ford et al. 1995. *Literature Reviews of the Life History, Habitat Requirements and Mitigation/Compensation Strategies for Thirteen Sport Fish Species in the Peace, Liard and Columbia River Drainages of British Columbia.* Canadian Manuscript Report of Fisheries and Aquatic Sciences 2321.)

Fort McKay Environmental Services. 1991. *Fort McKay Position Paper on the Environmental Effects of the Proposed OSLO Project.* 43 p. + App.

Fox, J.C. 1980. *Sand and Gravel Resources of the Athabasca Oil Sands Region, Northeastern Alberta.* Open File Report No. 1980-7. Alberta Energy and Utilities Board and Alberta Geological Survey.

Golder Associates Limited. 1995. *The Effect of Littoral Zone Area on Lake Productivity.* Prepared for Syncrude Canada Limited.

Golder Associates Limited. 1996. *Aquatic Baseline Report for the Athabasca, Steepbank and Muskeg Rivers in the Vicinity of the Steepbank and Aurora Mines.* 164 p. + App.

Golder Associates Limited. 1996. *Athabasca River Water Releases Impact Assessment.* Report for Suncor Energy Inc.

Golder Associates Limited. 1997. *Addendum to Syncrude Aurora Mine Environmental Baseline Program: Autumn 1996 Fisheries Investigations.* Draft report for Syncrude Canada Limited.

Golder Associates Limited. 1997. *Aquatic Resources Baseline Study for the Muskeg River Mine Project.* Prepared for Shell Canada Limited. 90 p. + App.

Golder Associates Limited. 1997. *Field-Scale Trials to Assess Effects of Consolidated Tails Release Water on Plants and Wetlands Ecology.* Prepared for Suncor Inc.

Golder Associates Limited. 1998. *Environmental Impact Assessment for the Muskeg River Mine Project.* 4 Volumes. Prepared for Shell Canada Limited.

Golder Associates Limited. 1998. *Oil Sands Regional Aquatics Monitoring Program (RAMP) 1997.* Prepared for Syncrude Canada Limited, Suncor Energy Inc. and Shell Canada Limited.

Golder Associates Limited. 1998. 1997 Synthesis of Environmental Information on Consolidated/Composite Tails (CT). Report for Suncor Energy Inc., Oil Sands Group, Fort McMurray, Alberta.

Golder Associates Limited and Conor Pacific Environmental Technologies Inc. 1998. *Technical Reference for the Meteorology, Emissions and Ambient Air Quality in the Athabasca Oil Sands Region.* Prepared for Suncor Energy Inc., Oil Sands Project Millennium.

Goudey, J.S., H.R. Hamilton, and B.R. Taylor. 1990. *Receiving Water Assessment for the Disposal of Treated Basal Aquifer Water and Secondary Swage to Kearl Lake.* HydroQual Canada Ltd. 85 p. + App.

Griffiths, W.H. and B.D. Walton. 1978. *The Effects of Sedimentation on the Aquatic Biota.* Prepared for the Alberta Oil Sands Environmental Research Program by Renewable Resources Consultants Ltd. AOSERP Report 35. 86 p.

Halsey, L. and D.H. Vitt. 1996. *Alberta Wetland Inventory Standards – Version 1.0. In: Nesby, R. (ed). Alberta Vegetation Inventory Standards Manual. 1997.* Alberta Environmental Protection Resource Data Division.

Hamilton, H.R., B.R. Taylor and G. Macdonald. 1990. *Water Quality Evaluation of the Proposed OSLO Effluent Discharge to the Athabasca River.* HydroQual Canada Ltd. 78 p. + App.

Hammer, U.T., R.C. Haynes, J.M. Hesseltine and S.M. Swanson. 1975. *The Saline Lakes of Saskatchewan.* Verh. Internat. Verein. Limnol. 19. p. 589-598.

Hartland-Rowe, R.C.B., R.W. Davies, M. McElhone, and R. Crowther. 1979. *The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta.* Prepared for the Alberta Oil Sands Environmental Research Program by the Department of Biology, University of Calgary. AOSERP Report 49. 144 p.

Harvey, C.A. 1998. *Basic Evaporative Emission Rates for Nonroad Engine Modeling.* Report No. NR-012. US EPA, Office of Mobile Sources.

Hesslein, R.H., 1977. *Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area.* Prepared for the Alberta Oil Sands Environmental Research Program by the Freshwater Institute, Environment Canada. AOSERP Report 71. 36 p.

HWC. 1995. *Guidelines for Canadian Drinking Water Quality.* Supporting Documentation.

HydroQual Laboratories Ltd. 1996a. *Laboratory Studies on Trophic Level Effects and Fish Health Effects of Suncor Tar Island Dyke Wastewater.* Report for Suncor Inc., Oil Sands Group, Calgary, Alberta.

HydroQual Laboratories Ltd. 1996b. *Laboratory Tests of Trophic Level Effects and Fish Health Effects and Tainting Potential of Suncor Refinery Effluent.* Report for Suncor Inc., Oil Sands Group, Calgary, Alberta.

Jacobs, F.S.U. 1982. The Nature and Significance of Trace Elements in Oil Sands and Heavy Oils. Washington State University, Department of Chemistry.

Jones, M.L., G.J. Mann, and P.J. McCart. 1978. *Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray:* Volume 1. Prepared for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 36. 71 p.

Khalil, M.A.K and R.A. Rasmussen 1990. *Atmospheric Methane: Recent Global Trends.* Environmental Science and Technology. Volume 24, No. 4. p. 549.

Lake, W. and W. Rogers. 1979. *Acute Lethality of Mine Depressurization Water to Trout-Perch (Percopsis omiscomaycus) and Rainbow Trout (Salmo gairdneri).* Volume 1. Prepared for the Alberta Oil Sands Environmental Research Program and Alberta Environment, Water Quality Control Branch. AOSERP Report 23. 44 p.

Lands and Forests. 1996. *Recommended Native Grasses and Legumes for Reclamation in the Green Area.*

Laurila, T. and H. Lattila. 1994. *Surface Ozone Exposures Measured in Finland.* Atmospheric Environment 28. p 53-68

Legge, A.H. and S.V. Krupa. 1990. *Acidic Deposition: Sulphur and Nitrogen Oxides.* Lewis Publishers Inc.

Lock, M.A., and R.R. Wallace. 1979. *Aquatic Biological Investigations of the Muskeg River Watershed.* Prepared for the Alberta Oil Sands Environmental Research Program by Freshwater Institute, Environment Canada. AOSERP Report 67. 29 p.

Lockhart, W. L., D.A. Metner. 1996. *Analysis of Liver mixed-Function Oxygenase in Fish, Peace, Athabasca and Slave River Basins, September to December, 1994.* Northern River Basins Study Project Report No. 132. 53 p.

MacFarlane, I.C. 1969. *Muskeg Engineering Handbook.* Canadian Building Series, University of Toronto Press, Toronto.

Machniak K. 1976. *The Impact of Saline Waters Upon Freshwater Biota (A literature Review and Bibliography).* Prepared for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 8. 258 p.

Malhotra, S.S. and A.A. Khan. 1984. *Biochemical and Physiological Impact of Major Pollutants. In: Treshow, A. (ed.). Air Pollution and Plant Life.* John Wiley & Sons, New York. p.113-157.

NRCB. 1992. *Application to Construct a Recreational and Tourism Project in the Town of Canmore, Alberta.* Decision Report Application 9103 - Three Sisters Golf Resorts Inc.

Oil Sands Vegetation Reclamation Committee. 1998. *Guideline for Reclamation to Forest Vegetation in the Alberta Oilsands Region.* Draft Report. 58 p. +App.

Oil Sands Vegetation Reclamation Committee. 1998. *Guidelines for Reclamation to Terrestrial Vegetation in the Alberta Oil Sands Region.* Calgary, Alberta. 58 p. +App.

Organic Materials as Soil Amendments in Reclamation: A Review of the Literature. 1993. Report RRTAC 93-4, Alberta Conservation and Reclamation Council, Reclamation Research Technical Advisory Committee, Alberta Environmental Protection, Edmonton. 228 p.

Ozoray et al. 1980. ARC, *Earth Sciences Report* 78-6.

Pederson, U. and A.S. Lefohn. 1994. *Characterizing Surface Ozone Concentrations in Norway.* Atmospheric Environment 28. p. 53-68.

Prepas E.E. and D.O.Trew. 1983. *Evaluation of the Phosphorus-Chlorophyll Relationship for Lakes Off the Precambrian Shield in Western Canada*. Can. J. Fish Aquat. Sci. 40:27-35.

R. L. & L. Environmental Services Ltd. 1989. *OSLO Project – Water Quality and Fisheries Resource Baseline Studies.* 127 p. + App.

R. Webb Environmental Services Ltd. 1980. *Lake and Pond Fisheries Survey – Alsands Project Area.* 33 p.

R.A. Bothe, C. Abraham. 1987. *Evaporation and Evapotranspiration in Alberta 1912 to 1985.* Hydrology Branch, Technical Services Division, Water Resources Management Services, Alberta Environment.

Renault, S. and J.J. Zwiazek. 1997. *Phytotoxicity of Reclaimed Fine Tails and Tailing Sands*. Prepared for Suncor Inc., Oil Sands Group and Syncrude Canada Limited.

Roberts, T.L., and H. Regier. 1989. *Long Term Soil Acidification Monitoring in Alberta from 1981 to 1988*. Soil Protection Branch, Waste and Chemicals Division, Alberta Environment, Lethbridge, Alberta. Unpublished Report.

Saffran and Trew. 1996. *Sensitivity of Alberta Lakes to Acidifying Deposition: An Update of Sensitivity Maps with Emphasis on 109 Northern Lakes*. Water Sciences Branch, Water Management Division, Alberta Environmental Protection.

Schwartz, F.W. 1980. *Hydrogeological Investigation of Muskeg River Basin, Alberta*. Department of Geology. AOSERP Report 87. 97 p.

Sekerak, A.D. and G.L. Walder. 1980. *Aquatic Biophysical Inventory of Manor Tributaries in the AOSERP Study Area. Volume 1: Summary Report*. Prepared for the Alberta Oil Sands Environmental Research Program by LGL Limited, Environmental Research Associates. AOSERP Report 114. 100 p.

Shell Canada Limited, 1975. *Environmental Impact Assessment – Lease 13 Mining Project Alberta Oil Sands.*

Shell Canada Limited. 1998. *Application for Approval of the Muskeg River Mine Project*, Volume 1.

Smith, S.L., D.D. MacDonald, K.A. Keenlyside and C.L. Gaudet. 1996. *The Development and Implementation of Canadian Sediment Quality Guidelines. In: Munawar, M. and G. Dave (editors). 1996. Development and Progress in Sediment Quality Assessment: Rationale, Challenges, Techniques and Strategies*. Ecovision World Monograph Series. SPB Academic Publishing, Amsterdam, The Netherlands. p. 233-249.

Suncor Inc., Oil Sands Group. 1996. *Steepbank Mine Project Application.*

Thomas, J.W. (ed.). 1979. *Wildlife Habitats in Managed Forest: the Blue Mountains of Oregon and Washington.* US Department. of Agriculture. Agriculture Handbook No. 553. 512 p.

Tripp, D.B. and P.J. McCart. 1979. *Investigations of the Spring and Spawning Fish Populations in the Athabasca and Clearwater Rivers Upstream from Fort McMurray*: Volume 1. Prepared for the Alberta Oil Sands Environmental Research Program by Aquatic Environments Limited. AOSERP Report 84. 128 p.

Tsuii, P.T.P., B.R. McMahon, P.J. McCart and J.V. McCart. 1980. *A Laboratory Study of Long-Term Effects of Mine Depressurization Groundwater on Fish and Invertebrates.* Prepared for the Alberta Oil Sands Environmental Research program by Aquatic Environments Ltd. AOSERP Report 113. 211 p.

UMA Engineering. 1991. *Environmental Impact Assessment Report for the Three Sisters Golf Resorts Inc. Destination Resort, Canmore, Alberta.* Vol. II.

US EPA. 1991. *Technical Support Document for Water Quality-Based Toxics Control.* Office of Water Regulations and Standards, Washington, D.C. EPA/505/2-90-001.

Walters, Thomas F. 1995. *Sediment in Streams: Sources, Biological Effects, and Control.* American Fisheries Society, Monograph 7.

Ward, J.V. and J.A. Stanford, 1979. *Ecological Factors Controlling Stream Zoobenthos with emphasis on Thermal Modification of Regulated Streams, in The Ecology of Regulated Streams.* Plenum Press, New York. 398 p.

W-E-R Engineering Ltd. 1989. *Environmental Evaluation of Alternative Headwater Diversions – for the OSLO Project.* 109 p. + App.

Wiederholm, T. 1984. *Responses of Aquatic Insects to Environmental Pollution. In V.H. Resh. And D.M. Rosenberg (eds), 1984. The Ecology of Aquatic Insects.* Praeger Publishers, New York, N.Y.

Xu, J.G. and R.L. Johnson. 1996. *Plant Growth, Dewatering and Contaminant Uptake from Oil Sands Fine Tails and Tailings.* Alberta Environmental Centre, Vegreville, Alberta. Prepared for Suncor Inc., Oil Sands Group.

7-Q-10 Discharge The minimum average discharge over a period of seven days duration which has a return period of 10 years; i.e., the probability that the minimum seven-day duration discharge will be equal to or less than the stated value is 10%.

a The metric symbol for year.

acidification The addition of acid to a solution until the pH falls below 7.

activity area A limited portion of a site in which a specialized cultural function was carried out, such as hide scraping, tool manufacture, food preparation and other activities.

additive A substance added to another substance in small amounts.

adsorption The surface retention of solid, liquid or gas particles by a solid or liquid.

adverse effect An undesirable effect to an organism (human, animal or plant), indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations or visible pathological changes.

AEP The abbreviation for Alberta Environmental Protection.

agglomeration A technique that combines small particles to form larger particles.

agitation tank A vessel in which slurry material is maintained in suspension by using an impeller or by recirculating the material with pumps.

Ah horizon An A horizon of organic matter accumulation containing less than 17 percent carbon.

airshed The geographic area requiring unified management for achieving air pollution control.

alkalinity A measure of water's capacity to neutralize an acid. It indicates the presence of carbonates, bicarbonates and hydroxides, and less significantly, borates, silicates, phosphates and organic substances. It is expressed as an equivalent of calcium carbonate. The composition of alkalinity is affected by pH, mineral composition, temperature and ionic strength. However,

alkalinity (cont'd)	alkalinity is normally interpreted as a function of carbonates, bicarbonates and hydroxides. The sum of these three components is called total alkalinity.
ambient air	The air in the surrounding atmosphere.
ambient noise	The pre-existing sound environment of a location, before the introduction of, or in absence of, noise from a specific source which also affects the sound environment of that location.
antiscalant	An additive which prevents the buildup of scale, such as from calcium or iron.
AOSCEHEAP	The abbreviation for Alberta Oil Sands Community Exposure Health Effects Assessment Program.
AOSTRA	The abbreviation for Alberta Oil Sands Technology Research Authority.
API	The abbreviation for the American Petroleum Institute.
aqueous mixture	A combination of substances, one of which is water.
aquifer	A water-saturated, permeable body of rock capable of transmitting significant or usable quantities of groundwater to wells and springs under ordinary hydraulic gradients.
aquifer depressurization	The process of reducing the natural hydrostatic pressure in an aquifer.
aquitard	A bed of low permeability adjacent to an aquifer, which might serve as a storage unit for groundwater, although it does not yield water readily.
asphaltene	Any of the dark, solid constituents of crude oil or bitumen that are soluble in carbon disulphide but insoluble in paraffin naphthas. They hold most of the organic constituents of bitumen.
ASTM	The abbreviation for the American Society for Testing Materials.
ATC	The abbreviation for Athabasca Tribal Council.
attenuation	A reduction in sound level that occurs with sound propagation over distance by means of physical dissipation or absorption mechanisms, or a reduction in sound level that occurs by means of noise control measures applied to a sound source.
Atterberg limits	A geometric and decimal grade scale for classifying particles in sediments based on the unit value of 2 mm and involving a fixed ratio of 10 for each successive grade. Subdivisions are geometric means of the limits of each grade.
AWI	The abbreviation for Alberta Wetlands Inventory.

bank cubic metre	A cubic metre of material in place.
baseline	A surveyed condition that serves as a reference point to which later surveys are coordinated or correlated.
basic sound level	The allowable sound level at a residential location, as defined by the current EUB Directive, with the inclusion of industrial presence based upon dwelling unit density and proximity to transportation noise sources.
BAW	The abbreviation for beach above water.
bbl	The abbreviation for barrel.
bbl/d	The abbreviation for barrels per day.
bbl/yr	The abbreviation for barrels per year.
BBW	The abbreviation for beach below water.
bcm	The abbreviation for bank cubic metres.
bedrock	The body of rock that underlies gravel, soil or other superficial material.
benthic invertebrates	Organisms that live at the bottom of lakes, ponds or streams.
berm	A mound or wall of earth.
BHP	The abbreviation for The Broken Hill Proprietary Company Limited.
biogenic	Essential to the maintenance of life.
BIP	The abbreviation for bitumen in place.
bioaccumulation	The process of an organism storing in its body a higher concentration of a substance than is found in the environment.
bioavailability	The amount of a substance that enters the body following administration of, or exposure to, the substance.
biocide	A chemical agent that destroys pests. Also known as *pesticide*.
biodiversity	The variety of organisms and ecosystems within particular habitats.
biophysics	The application of physical principles and methods to study and explain the structures of living organisms.
bioremediation	The process of applying corrective action to unbalanced biological systems.

bitumen	A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that might contain sulphur compounds and that, in its naturally occurring state, will not flow to a well.
bitumen froth	Air-entrained bitumen with a froth-like appearance that is the product of the primary extraction step in the warm or hot water extraction process.
bitumen grade	The amount of bitumen in oil sands, usually expressed as a percentage.
boiler feed water	Water that meets required purity specifications and is used in the heat recovery steam generator to produce steam.
borehole	The hole made by drilling or boring.
BS&W	The abbreviation for basic sediment and water.
BTU	The abbreviation for British thermal unit.
°C	The symbol for degrees Celsius.
$CaOH_2$	The chemical formula for calcium oxide.
C&R	The abbreviation for conservation and reclamation.
CANMET	The acronym for the Canadian Centre for Mineral and Energy Technology.
CASA	The abbreviation for Clean Air Strategic Alliance.
CCME	The abbreviation for the Canadian Council of the Ministers of the Environment.
CEA	The abbreviation for cumulative effects assessment.
CEAA	The abbreviation for Canadian Environmental Assessment Agency.
centre reject material	Sand and clay material that is interbedded with the bitumen ore.
centrifuge	A rotating device for separating, by centrifugal force, suspended particles in solution, according to particle-size fractions.
CEPA	The abbreviation for the Canadian Environmental Protection Act.
CES	The abbreviation for cumulative effects study.
CH_4	The chemical formula for methane.
chronic toxicity	The development of adverse effects after an extended exposure to relatively small quantities of a chemical.
cm/a	The metric symbol for centimetres per year.

CML	The abbreviation for Consolidated Metis Locals.
CO_2	The chemical formula for carbon dioxide.
cofferdam	A temporary damlike structure constructed around an excavation to exclude water.
cogeneration	The simultaneous on-site generation of electrical power and process steam or heat from the same plant.
coke	A solid residue that contains mainly carbon produced from the (dry) distillation of petroleum or carbonaceous materials.
coker	The processing unit in which coking occurs.
commissioning	The act of setting up equipment and facilities for service.
compaction	The process of pore space reduction in soil or sediments from heavier overlying material weighing the soil down.
conceptual model	A model developed during early risk assessment that describes several working hypotheses.
condensate	A light hydrocarbon liquid obtained by condensing hydrocarbon vapours. Condensate typically contains mostly propane, butane and pentane.
conditioning tank	A vessel in which product is treated with additives to give it certain properties.
CONRAD	The acronym for Canadian Oilsands Network for Research and Development.
consolidation	The process by which a loose, soft or liquid substance becomes coherent and firm.
consolidated tailings	A non-segregating mixture of plant tailings that consolidates quickly in tailings deposits.
construction phase	The project stage involving building the plant and facilities and preparing for start-up.
contaminant	A substance added to a receiving environment in excess of natural concentrations.
contamination	The process of making unfit for use by introducing unwholesome or undesirable elements.
contouring	The process of shaping the land surface to fit the form of the surrounding land.

crude oil	Unrefined liquid petroleum.
crusher	A machine for crushing rock or other materials.
cryosolic soil	An order of mineral or organic soils proposed for adoption in the Canadian taxonomic system.
CT	The abbreviation for consolidated tailings.
cut-off grade	The grade value below which an ore cannot be extracted economically.
deaerator	A device in which oxygen, carbon dioxide, or other noncondensable gases are removed from boiler feedwater, steam condensate, or a process stream.
debottlenecking	The act of increasing the capacity of specific pieces of equipment, or parts of a process, to increase the capacity of the whole process.
decommissioning	The act of removing equipment and facilities from service.
deionization	An ion-exchange process in which all charged species or ionizable organic and inorganic salts are removed from solution.
density	The mass or weight of a substance per unit volume.
Devonian	The fourth period of the Paleozoic Era.
DFO	The abbreviation for the Department of Fisheries and Oceans.
DIAND	The abbreviation for the Department of Indian Affairs and Northern Development.
dilbit	A blend of diluent and bitumen.
diluent	The diluting agent added to bitumen to lower viscosity.
ditch	A long, narrow excavation dug in the earth for drainage.
dose	A measure of integral exposure. Examples include the amount of chemical ingested, the amount of a chemical taken up, and the product of ambient exposure concentration and duration of the exposure.
dyke	A bank of earth constructed to confine water.
ecosite	A subdivision of an ecosection, described and analyzed in detail.
ecosystem	An integrated and stable association of living and nonliving resources functioning within a defined physical location.
effluent	A stream of water discharging from a source.

EIA	The abbreviation for Environmental Impact Assessment.
ELC	The abbreviation for ecological land class.
emergency response	The action taken after an event to minimize the consequences of an emergency.
emissions	Substances discharged into the atmosphere through a stack. See also *stack emissions* and *fugitive emissions.*
emulsion	A stable dispersion of one liquid in a second liquid that will not mix with the first liquid.
endangered species	A species facing imminent extirpation or extinction in Canada..
end-pit lake	An artificial lake, used to fill the void at one end of a mine, into which the remaining fine tailings at the end of mine life are discharged and stored under a water cap.
environmental impact assessment	A review of the effects that a proposed development will have on the local and regional environment.
EPA	The abbreviation for Environmental Protection Agency.
EPC	The abbreviation for engineering, procurement and construction.
EPCM	The abbreviation for engineering, procurement and construction management.
EPEA	The abbreviation for Environmental Protection and Enhancement Act.
epilimnion	A freshwater zone of relatively warm water in which mixing occurs as a result of wind action and convection currents.
EPL	The abbreviation for end-pit lake.
ER	The abbreviation for exposure ratio.
erosion	The process by which material, such as rock or soil, is worn away or removed by wind or water.
ERT	The abbreviation for electrical resistivity tomography.
EUB	The abbreviation for Alberta Energy and Utilities Board.
exceedance	An emission whose measured value is more than that allowed by government regulations.
exposure	The contact between a chemical and a biological system or organism.

extirpation	The act of uprooting, destroying, making extinct or exterminating.
extraction	The process of separating bitumen from the oil sands.
fallback position	An alternative course of action.
facies	Part of a bed of sedimentary rock that differs significantly from the rest of the bed.
facilities	The surface equipment and pipelines required for mining and extraction operations.
FC	The abbreviation for Fluvial Channel Sand facies.
FEED	The abbreviation for front-end engineering and design.
feed ore	Bitumen ore that is processed in the extraction plant.
feedstock	Raw material supplied to a processing or refining facility.
fenceline approval	Approval for development activities within the boundaries of a lease area.
fens	Peat land covered by water, especially in the upper regions of old estuaries and around lakes, that can be drained only artificially.
FGD	The abbreviation for flue gas desulphurization.
fibrous	Capable of being separated into fibres.
fine tailings	A suspension of fine silts, clays residual bitumen and water produced during bitumen extraction from oil sands.
fines	Silt and clay particles.
flare stack	A chimney used to dispose of surplus hydrocarbon gases by igniting them in the atmosphere.
floating roof tank	A tank with a roof made of steel, plastic, sheet or microballoons, which floats upon the surface of the stored liquid. Floating roofs are used to decrease the vapour space and reduce the potential for evaporation.
flocculant	A reagent added to a dispersion of solids in a liquid to bring together the fine particles to form flocs.
flocs	Small masses formed in a fluid through coagulation, agglomeration or biochemical reaction of fine suspended particles.

flue gas desulphurization	A process involving the removal of a substantial portion of sulphur dioxide from the combustion gas (flue gas) formed from burning petroleum coke. Desulphurization is accomplished by contacting the combustion gases with a solution of limestone. Gypsum ($CaSO_4$) is formed as a byproduct of this process.
fluvial channel	A channel formed by a stream or river action.
fluvial deposits	All sediments, past and present, deposited by flowing water.
forecast	An estimate or prediction of future conditions.
formation	A geologic unit of distinct rock types that is large enough in scale to be mappable over a region.
FPOB	The abbreviation for Flood Plain and Overbank facies.
froth	A type of foam in which solid particles are also dispersed in the liquid, in addition to gas bubbles. The solid particles may be the stabilizing agent.
fresh water	Water that is not salty, especially when considered as a natural resource.
fugitive emissions	Trace amounts of uncombusted substances that are released into the atmosphere during normal facility and plant operations.
GJ	The metric symbol for gigajoules.
glacial till	Unsorted sedimentary material deposited directly by and underneath a glacier, consisting of a mixture of clay, silt, sand, gravel and boulders. Also known as *glacial deposits.*
glaciofluvial deposits	Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice.
gland	A device used to form a seal around a pump to prevent fluid leakage.
grade	A measure of the quality of raw ore, usually expressed as a percentage of the content of a particular component. See also *bitumen grade.*
grading	The process of leveling off to a smooth horizontal or sloping surface.
groundwater	Subsurface water that occurs beneath the water table in soils and geological formations that are fully saturated. It is the water within the earth that supplies water wells and springs.
grubbing	The process of clearing stumps and roots from land.
GSI	The abbreviation for gonadal somatic index.
gypsum	A mineral ($CaSO_4$ $2H_2O$).

ha	The abbreviation for hectare.
habitat	The part of the physical environment in which a plant or animal lives.
hazardous waste	Any waste material that presents a potential for unwanted consequences to people, property and the environment.
HHV	The abbreviation for higher heating value.
historical resources	Works of nature or by humans valued for their palaeontological, archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest.
historical resources impact assessment	A review of the effects that a proposed development will have on the local and regional historic and prehistoric heritage of an area.
HNO_3	The chemical formula for nitric acid.
HRIA	The abbreviation for historical resources impact assessment.
HIS	The abbreviation for Wildlife Habitat Suitability Indices.
Human Health Risk Assessment	The process of defining and quantifying risks and determining the acceptability of those risks to human life.
HV	The abbreviation for heating value.
hydraulic gradient	In an aquifer, the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.
hydrocarbons	One of a very large group of chemical compounds composed only of carbon and hydrogen; the largest source of hydrocarbons is from petroleum crude oil.
hydroconversion	The process of adding hydrogen to medium and heavy oils to produce light oil products.
hydrogeology	The study of the factors that deal with subsurface water (groundwater), and the related geological aspects of surface water.
hydrotransport	A method of transporting granular material, such as oil sands or extraction tailings, in a water-based slurry in a pipeline.
hypolimnion	The lower level of water in a stratified lake, characterized by a uniform temperature that is generally cooler than that of other strata in the lake.
IC	
impervious	Not allowing water or other fluid to pass through.

infrastructure	Basic facilities, such as transportation, communications, power supplies and buildings, which enable an organization, project or community to function.
interburden	Waste material located between economically recoverable oil sands.
Inversion	The process by which one type of emulsion is converted to another.
invertebrate	An animal without a backbone and internal skeleton.
IRC	The abbreviation for Industry Relations Corporation.
isopach map	A geological map of subsurface strata showing the various thicknesses of a given formation underlying an area.
isopleth	The straight line which cuts the three scales of a nomograph at values satisfying some equation.
karst	A topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.
keq	The metric symbol for killiequivalent.
keq/ha/a	The metric symbol for killiequivalent per hectare per year.
kg	The metric symbol for kilogram.
kg/d	The metric symbol for kilograms per day.
kg/h	The metric symbol for kilograms per hour.
kg/m	The metric symbol for kilograms per metre.
kg/s	The metric symbol for kilograms per second.
KIRs	The abbreviation for key indicator resources.
km	The metric symbol for kilometre.
km/h	The metric symbol for kilometres per hour.
kPa	The metric symbol for kilopascal.
kPa(g)	The metric symbol for kilopascal gauge.
kV	The metric symbol for kilovolt.
kW	The metric symbol for kilowatt.
L	The metric symbol for litre.

leachate	A solution formed by leaching.
leaching	The process of dissolving soluble minerals or metals out of an ore.
LEE	The abbreviation for low energy extraction process.
LHV	The abbreviation for lower heating value.
lift	The horizontal surface, adjacent to the mine face, upon which mining equipment operates.
littoral zone	The biogeographic zone between the high and low-water marks.
L/s	The metric abbreviation for litres per second.
LSA	The abbreviation for local study area.
M	The metric symbol for mega.
m	The metric symbol for metre.
m^2	The metric symbol for square metre.
m^3	The metric symbol for cubic metre.
m^3/a	The metric symbol for cubic metres per annum.
m^3/d	The metric symbol for cubic metres per day.
macronutrient	A large substance that provides nutrition.
makeup water	The process water required to replace that lost by evaporation or leakage in a closed-circuit, recycle operation.
masl	The abbreviation for metres above sea level.
material balance	A calculation to inventory material inputs versus outputs in a control system.
mature fine tailings	Fine tailings that have dewatered to about 30% solids during the three years following deposition.
Mbbl	The abbreviation for millions of barrels.
merchantable timber	The coniferous and deciduous trees that are cut down during site clearing and that can be sold.
MFT	The abbreviation for mature fine tailings.
mg	The chemical formula for magnesium.

mg/L	The metric symbol for milligrams per litre.
Microtox	A toxicity test that includes assaying light produced by a strain of luminescent bacteria.
min	The abbreviation for minute.
mitigate	To cause to become less harsh or hostile.
MLD	The abbreviation for McLelland (soil type).
mm	The metric symbol for millimetre.
modeling	A simplified representation of a relationship or system of relationships. Modeling involves calculation techniques used to make quantitative estimates of an output parameter based on its relationship to input parameters. The input parameters influence the value of the output parameters.
monitoring	The process of measuring continuously, or at intervals, a condition that must be kept within set limits.
MSL	The abbreviation for mineral surface lease.
μ	The metric symbol for micron.
MUS	The abbreviation for Muskeg (soil type).
Muskeg	A thick deposit of partially decayed vegetable matter of wet boreal regions.
MW	The metric symbol for megawatt.
naphtha	A petroleum fraction with volatility between gasoline and kerosene.
neutralization	The process of making a solution neutral (neither acidic nor basic, and with a pH of 7), by adding a base to an acidic solution or an acid to a basic solution.
NO_2	The chemical formula for nitrogen oxide.
NO_3	The chemical formula for nitric acid.
NOEC	The abbreviation for No Observable Effects Concentration. The highest concentration in a medium that does not cause a statistically significant difference in effect as compared to controls.
NO_x	The chemical formula for oxides of nitrogen.

nomograph	A chart which represents an equation containing three variables by means of three scales, so that a straight line cuts the three scales in values of the three variables satisfying the equation.
nonpotable water	Water unfit for human consumption.
Non-toxic	Not poisonous.
NPV	The abbreviation for net present value.
NQ	The abbreviation for not quantified.
NRB	The abbreviation for net recoverable bitumen.
NRBS	The abbreviation for the Northern River Basin Study.
NWPA	The abbreviation for Navigable Waters Protection Act.
Nutrients	Environmental substances, such as nitrogen or phosphorous, that are necessary for the growth and development of plants and animals.
O_3	The chemical formula for ozone.
OB	The abbreviation for overburden.
OBIP	The abbreviation for original bitumen in place.
OD	The abbreviation for outside diameter.
oil sands	An unconsolidated, porous sand formation or sandstone containing or impregnated with petroleum or hydrocarbons.
oligotrophic	Of a lake, lacking plant nutrients and usually containing plentiful amounts of dissolved oxygen without marked stratification.
operating costs	The dollar amount required to run a facility or organization.
operations phase	The project stage involving oil sands mining and bitumen extraction.
orebody	A solid and fairly continuous mass of ore, which may include low-grade ore and waste as well as pay ore, but is individualized by form or character from adjoining country rock.
ore grade	A measure of the quality of raw ore, usually expressed as a percentage of bitumen content.
ore deposit	Rocks containing minerals of economic value in an amount that can be profitably exploited.

ore reserve	The total tonnage and average value of proved ore, plus the total tonnage and assumed value of the probable ore.
organic matter	The fraction of a soil that contains plant and animal residues in various stages of decomposition.
OSEC	The abbreviation for Oil Sands Environmental Coalition.
overburden	All material, including soil, sand, silt or clay, that has to be removed to expose the ore before it can be mined.
PAH	The abbreviation for polycyclic aromatic hydrocarbon.
Paleosol	An ancient soil horizon.
paraffinic solvent	A solvent made up of a mixture of pentane and hexane.
particulate emissions	Emissions of fine particles of liquid or solid.
paste technology	A method of thickening fine clay particles by adding chemical polymers.
patch	A term used to recognize that most ecosystems are not homogeneous, but exist as a group of patches or ecological islands that are recognizably different from the parts of the ecosystem that surround them but nevertheless interact with them.
permeability	The capacity of a porous rock, soil, or sediment for transmitting a fluid without damaging the structure of the medium.
permissible sound level	The allowable overall A-weighted sound level of noise from energy industry sources, as specified by the EUB Noise Control Directive, which may contribute to the sound environment of a residential location.
pervious	A rock, soil or sediment that can transmit a fluid without structural alteration.
pH value	The measurement of a substance's acidity or alkalinity.
piezometer	An instrument for measuring fluid pressure.
PM	The abbreviation for particulate matter.
PMF	The abbreviation for probable maximum flood.
PMP	The abbreviation for probable maximum precipitation.
porewater	The fluid filling the small spaces between particles of rock.
potable water	Water that is suitable for drinking.

ppm	The abbreviation for parts per million.
precipitation	The rain or snow that falls on the earth's surface.
prestripping	The process of removing overburden from the surface of the land in preparation for mining.
procurement	The process of obtaining materials, equipment and services, including purchasing, contracting and negotiating directly with the source of supply.
production forecast	The amount of oil expected to be recovered within a particular time frame.
PSD	The abbreviation for paraffinic solvent demulsification.
QA	The abbreviation for quality assurance.
Quaternary	The most recent geologic time period, encompassing the last two million years.
QC	The abbreviation for quality control.
radiotelemetry	The process of obtaining data at a location remote from the source of the data, using radio waves for transmitting the data.
RAMP	The abbreviation for Regional Aquatics Monitoring Program.
RAQCC	The abbreviation for the Regional Air Quality Coordinating Committee.
reclamation	The process of stabilizing and returning disturbed land to a natural state of equivalent or better capability.
reclaimed landscape	An area that has undergone reclamation.
recycled water	Water that is stripped from the oil sands during the extraction process and treated for reuse in the process.
RDR	The abbreviation for Regional Development Review.
reclamation	The restoration of disturbed or waste land to a state of useful capability. Reclamation is the initiation of the process that leads to a sustainable landscape, including the construction of stable landforms, drainage systems, wetlands, soil reconstruction, addition of nutrients and revegetation. This provides the basis for natural succession to mature ecosystems suitable for a variety of end uses.
regenerant	A solution that restores the activity of an ion-exchange bed.
RIWG	The abbreviation for the Regional Infrastructure Working Group.

rejects	Material, such as clay or lean oil sands, that do not pass through the extraction sizing screens and are, therefore, excluded from the process.
reserves	The unproduced but recoverable bitumen in a formation that has been proven by production.
resin	A solid or semisolid organic product of natural or synthetic origin that has no definite melting point. Most resins are polymers.
resource	A natural source of revenue, such as oil or gas.
revegetation	The process of providing denuded land with a new cover of plants.
revetment	A facing made on a soil or rock embankment to prevent scour by weather of water.
riffle	Shallows across a stream bed over which water flows swiftly and is broken into waves by submerged obstructions.
right-of-way	The right of passage or of crossing over someone else's land. An easement in lands belonging to others that is obtained by agreement or lawful appropriation for public or private use.
riparian corridors	Corridors that are located on a riverbank.
riprap	A foundation or revetment in water or on soft ground made of irregularly placed stones or pieces of boulders; used chiefly for river and harbour work, for roadway filling, and on embankments.
RMWB	The abbreviation for Regional Municipality of Wood Buffalo.
rotary breaker	A rotating screen and lump breaker into which oil sands and hot water are added.
royalties	The share of profits reserved by the body granting an oil or mining lease.
RSA	The abbreviation for regional study area.
runoff	The portion of precipitation (rain and snow) that ultimately reaches streams via surface systems.
sandstone	A sedimentary rock composed of individual grains of sand cemented together.
sedimentary rock	A rock composed of materials that were transported to their present position by water or wind.
sedimentary sequence	The particular order in which rock layers occur.

sedimentary zone	A sedimentary rock stratum that is different from or distinguished from another stratum.
sedimentation pond	A small waterbody where suspended solid particles settle out and are deposited at the bottom of the pond.
seepage	The slow movement of water or other fluids through a porous medium, or through small openings in the surface of unsaturated soil.
SEIA	The abbreviation for socio-economic impact assessment.
sensible heat	The heat absorbed or evolved by a substance during a change of temperature that is not accompanied by a change of state.
separator	A vessel designed to separate the oil phase in a petroleum fluid from some or all of the other three constituent phases (gas, solids and water).
separation	The process of isolating components in streams of mixed fluids.
Shell	The abbreviation for Shell Canada Limited.
shutdown	The process of stopping equipment or machinery or a process, partly or completely.
site, historic	Any location with detectable evidence of past human activity.
slash	Debris, such as logs, chunks of wood, bark, and branches, in an open forest tract.
slash burning	The process of clearing vegetation from the land and setting fire to the remaining undergrowth.
slurry	A free-flowing, pumpable suspension of fine solid material in liquid.
SMART	The abbreviation for Shell McKay Application Review Team.
socio-economics	The study of social and economic factors.
soil capability	The measure of a soil's capacity to sustain vegetation.
SO_x	The chemical symbol for oxides of sulphur.
spudded	A hole that has been drilled.
SR	The abbreviation for strip ratio.
SRU	The abbreviation for solvent recovery unit.
stack	The portion of a chimney rising above the roof.

stack emissions	Substances discharged into the atmosphere through a plant stack.
stakeholder	People or organizations with an interest or share in an undertaking, such as a commercial venture.
start-up	The act of restarting work or energizing machinery or equipment after a temporary shutdown or commissioning.
start-up water	The additional volume of water required temporarily to start up a new development.
sterilization of ore	The process of making ore recovery uneconomical.
stockpile	A gradually accumulated reserve of material.
stratigraphy	A branch of geology that deals with the arrangement of rock layers.
Suncor	The abbreviation for Suncor Energy Inc.
surfactant	Any substance that lowers the surface or interfacial tension of the medium in which it is dissolved. Surfactants may be naturally occurring or a soluble chemical compound.
surficial aquifer	A surficial deposit containing water considered an aquifer.
surge	The accumulation of liquid above a normal or average level, or a sudden increase in its flow rate above a normal flow rate.
surge tank	A vessel through which liquids or gases are passed to ensure steady flow and eliminate pressure surges.
sustainability	The process of managing biological resources (e.g., timber, fish) to ensure replacement by regrowth or reproduction of the part harvested before another harvest occurs.
sustainable landscape	Landscape that can survive extreme events and natural cycles of change without being subjected to accelerated erosion or environmental impacts more severe than those of the natural environment.
Syncrude	The abbreviation for Syncrude Canada Limited.
synthetic crude oil	Oil obtained by refining heavier hydrocarbons.
t	The metric symbol for tonnes.
t/d	The metric symbol for tonnes per day.
t/h	The metric symbol for tonnes per hour.

tailings	A by-product of oil sands extraction comprising water, coarse sand, fine minerals and minor amounts of rejected bitumen waste.
tailings settling pond	An artificial impoundment structure to contain tailings. Tailings settling ponds are enclosed by dykes made with tailings and overburden materials to stringent geotechnical standards.
TEEM	The abbreviation for Terrestrial Environmental Effects Monitoring.
TERRE	The abbreviation for Terrestrial Reclamation on Challenging Material Research Program.
TFT	The abbreviation for thin fine tailings.
third-party services	Services contracted by one organization to another.
TID	The abbreviation for Tar Island Dyke.
timber salvage	The process of clearing the land of trees and retaining the trees to be sold for various uses.
topography	The configuration of a surface including its relief and natural and artificial features.
toxicity	The kind and amount of poison possessed by a chemical substance not of biological origin.
tremie	An apparatus for placing concrete underwater, consisting of a large metal tube with a hopper at the top end and a valve arrangement at the bottom, submerged end.
truck-and-shovel mining	The process of using large trucks and shovels to obtain ore from the ground.
TSRU	The abbreviation for tailings solvent recovery unit.
TSS	The abbreviation for total suspended solids.
turbine	A rotary engine, usually made with a series of curved vanes on a central spindle, that is actuated by a current of fluid, such as water, steam or air.
TUa	The abbreviation for acute toxicity units.
TV	The abbreviation for total volume.
TV/BIP	The abbreviation for the ratio of total volume to bitumen in place.
TV/NRB	The abbreviation for the ratio of total volume to net recoverable bitumen.

upgrader	A system of process units that uses either hydrogen addition or carbon rejection to convert bitumen or heavy oil to light oil products or light oil components.
US EPA	The abbreviation for the United States Environmental Protection Agency.
UTF	The abbreviation for underground test facility.
utilities	The supply of electricity, natural gas, water and sewer drains.
utility corridor	A right-of-way containing pipelines, power lines and road access.
vapour recovery	The process of capturing and recycling process water vapour in a closed-circuit system.
viscosity	The fluid property that characterizes the amount of functional energy loss during flow.
VOCs	The abbreviation for volatile organic compounds.
vol%	The abbreviation for volume percent.
VRU	The abbreviation for vapour recovery unit.
waste	All solids, liquids and sludge produced in the course of constructing, operating and abandoning the facilities.
waste management plan	The system developed to track and control emissions and waste and evaluate pollution-prevention steps.
water management plan	The system developed to optimize the use of available water supplies.
waterbody	A natural geographical feature containing water, such as a lake or stream.
watershed	An area bounded peripherally by a divide and draining ultimately to a particular watercourse or waterbody.
water table	The upper surface of groundwater or the level below which the soil is saturated with water. Also known as *phreatic surface.*
WBEA	The abbreviation for Wood Buffalo Environmental Association.
wellbore	The hole drilled by the bit in a well.
WET	The abbreviation for whole effluent toxicity.
wetlands	A broad group of wet habitats where the water table is usually at or near the surface or the land is covered by shollow water.
wt%	The abbreviation for weight percent.

Appendix A

TRADITIONAL LAND USE STUDY
SHELL MUSKEG RIVER
MINE PROJECT

PREPARED BY:

FORT MCKAY ENVIRONMENT SERVICES LTD.
AND
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PREPARED FOR:

SHELL CANADA LIMITED

MARCH, 1998

SHELL MUSKEG RIVER
OIL SANDS MINE PROJECT

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SHELL MUSKEG RIVER
OIL SANDS MINING PROJECT

1.0 INTRODUCTION:

1.1 Traditional Land Use Study

A Traditional Land Use Study provides information on the types of uses of land, flora, and fauna by a traditional culture within their traditional area of use. This document provides this information for the Treaty Indians of Cree and Chipewyan heritage, the Metis, and non status Indians of the Community of Fort McKay.

The Fort McKay community is located approximately 60 kilometres north of Fort McMurray, Alberta, on Highway 63. It is a community of approximately 350 people. Within a larger context, Fort McKay is located in a region underlain by rich oil sands deposits. Research on the oil sands resulted in the development of the Clark Extraction Process, which was first brought into commercial production by Great Canadian Oil Sands (Now Suncor) in the early 1960's, followed in the late 1960's by the establishment of Syncrude extraction facility.

Both Suncor Energy and Syncrude Canada have embarked on major expansions to their current operations. These expansions include the Suncor Steepbank Mine and Fixed Plant Expansion, Syncrude's Aurora Oil Sands Mine, and Suncor's Project Millennium. In addition to Shell's planned Muskeg River Mining project, Mobil, Petro Canada, Gulf and Solv-Ex have all embarked on oil sands development projects which are in various stages of preparations

The purpose of this Traditional Land Use Study is to provide information to the oil and gas industry regarding the area in which these companies plan to locate their operations. The study provides this information on both a regional and a site specific basis.

1.2. Objectives:

Land use studies cannot be considered complete when they only describe what has traditionally happened on the land. The relationship between the people and the land, and the culture and the land, must be understood to ensure that the concept of traditional Land use is understood. This is especially true when analyzing land use by a traditional culture with a hunting and gathering history, as is the case with the community of Fort McKay.

A land use study also cannot be considered complete when restricted to an isolated area. Site specific information should be given within a larger, regional context to complete the overall picture. Again, this is especially true of a hunting and gathering society, utilizing the resources of a large region. Any one specific site may have been utilized to a greater extent during one time period, and to a lesser extend during others.

Taking the needs of the community of Fort McKay , industry and the above items into account, the primary objectives of this Traditional Land Use Study are threefold:

They are:

- To provide information on the Fort Mckay Community to facilitate understanding of traditional land uses.

- To provide traditional land use information on a regional and site specific basis, and

- To Provide traditional land use information to the oil and gas industries which are looking to develop their own projects in the region.

1.3 Methodology:

Information was collected by conducting a literature review of relevant Fort McKay documents, maps provided to Fort McKay by provincial Agencies, consulting groups, and oil companies. (Appendix A.) In addition, information was collected from interviews held with members of the community of Fort McKay.

This study was limited by the probability that some traditional land use information has been lost because communication until recently was oral and anecdotal, leaving the situation open to loss of important historic information through the inevitable fuzziness of memory which occurs over millennia when no written records were kept. For this reason, every effort should be made to record for posterity, the stories told by the elders before they pass away and all of their knowledge is lost.

2. THE FORT MCKAY COMMUNITY

2.1 History of the Fort McKay Community:

From Where We Stand (Fort McKay Tribal Administration, 1983) provides a social and cultural history of Fort McKay and the traditional land use and economy related to that history. This section is a brief overview based on that document and subsequent discussions held with the Fort McKay Community members.

The current area of settlement known as Fort McKay is one of the traditional areas of use by the aboriginal peoples who have occupied the region since "time immemorial." It is likely that aboriginal peoples have existed in the region since the retreat of the last glacier. The current settlement area is part of the traditional seasonal movement based on hunting, trapping, fishing and gathering within the larger region.

The traditional economy of the Indians, now referred to as a "bush" economy, was centred on meat and fish, the gathering of roots and berries, and the related movement through the region. The economy, lifestyle and use of the land was part of the hunting, and gathering society. When the fur trade was introduced, the traditional economy expanded to include harvesting of furs for trade, but this did not affect the Indian need for, and the use of, plants and animals in the region. This was not an individual oriented economy as the hunting/gathering successes of individuals were realized by the whole community through the sharing tradition.

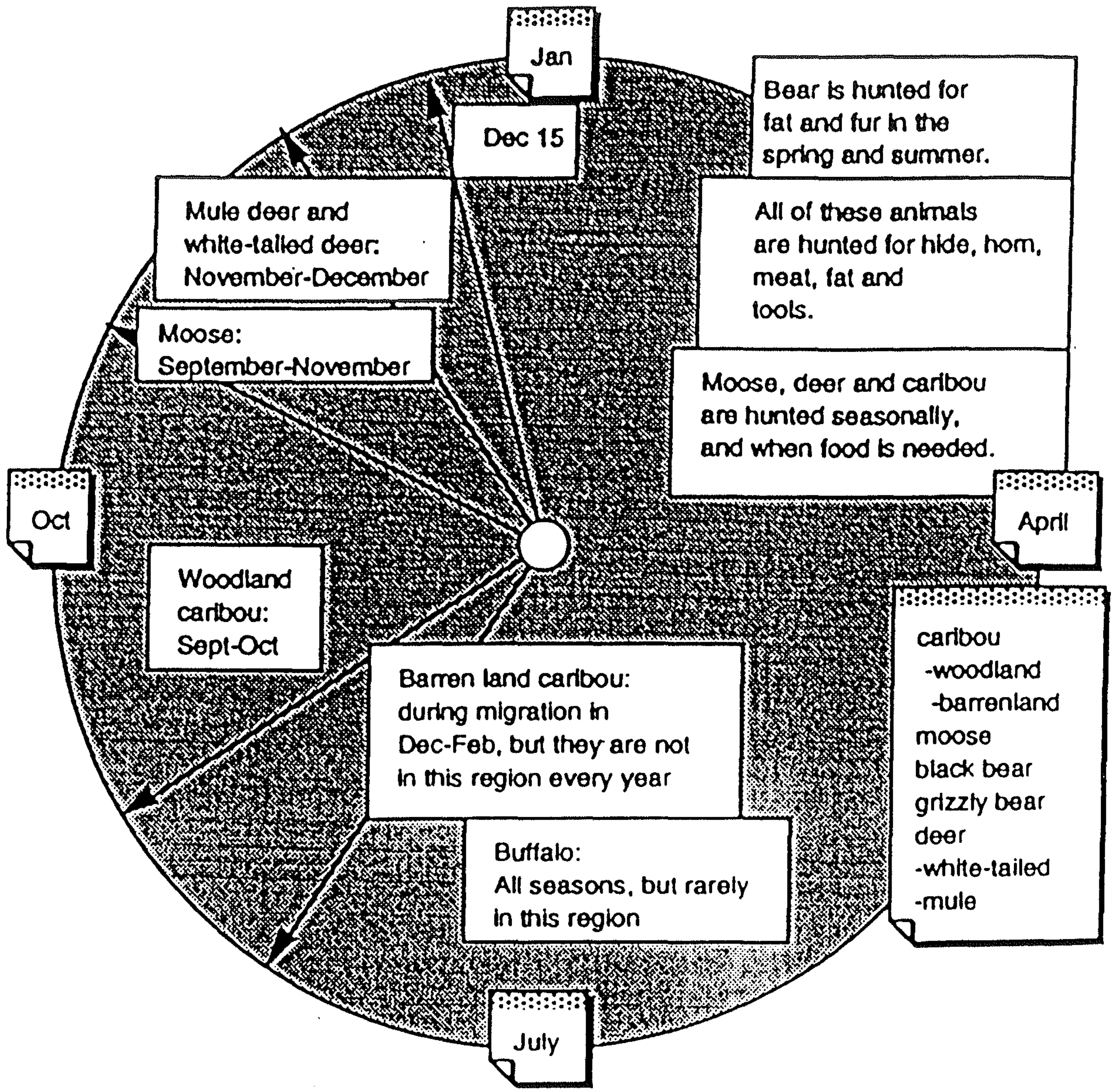
In 1899, the Chipewyan and Cree Indians of Fort McKay, signed Treaty 8. According to the Elders of the community, it was understood at the time of signing that lands would be put aside in reserve for their people and they had the right to hunt, trap, fish, and gather in the region as they wished. Reserve lands were allocated to the Fort McKay First Nation Band within their traditional land use areas. The first of these areas was located east, across the Athabasca River from the current location of Fort McKay, the second was located on the south shore of Gardiner Lakes, and the last was located adjacent to the northeast shore of Namur Lake.

In the 1930's, the government implemented the registered trap line system (Fish and Wildlife has recently stated that trap line registration commenced in the 1940's). Many of the aboriginal people in the area were unable to secure trap lines in their traditional land use area. In the 1960's, trap lines were changed from a linear system to and area system.

With the advent of the Family allowance and mandatory schooling for children in the mid-20th century, the community of Fort McKay has been permanently occupied . Traditionally, families and family groups moved throughout the region according to the pre-1960 seasonal round (Figure 1, following page). Permanent settlement for women and children was required for schooling. This had the effect of changing the traditional bush economy seasonal round to that which is illustrated in Figure 2.

Seasonal round for harvesting big game

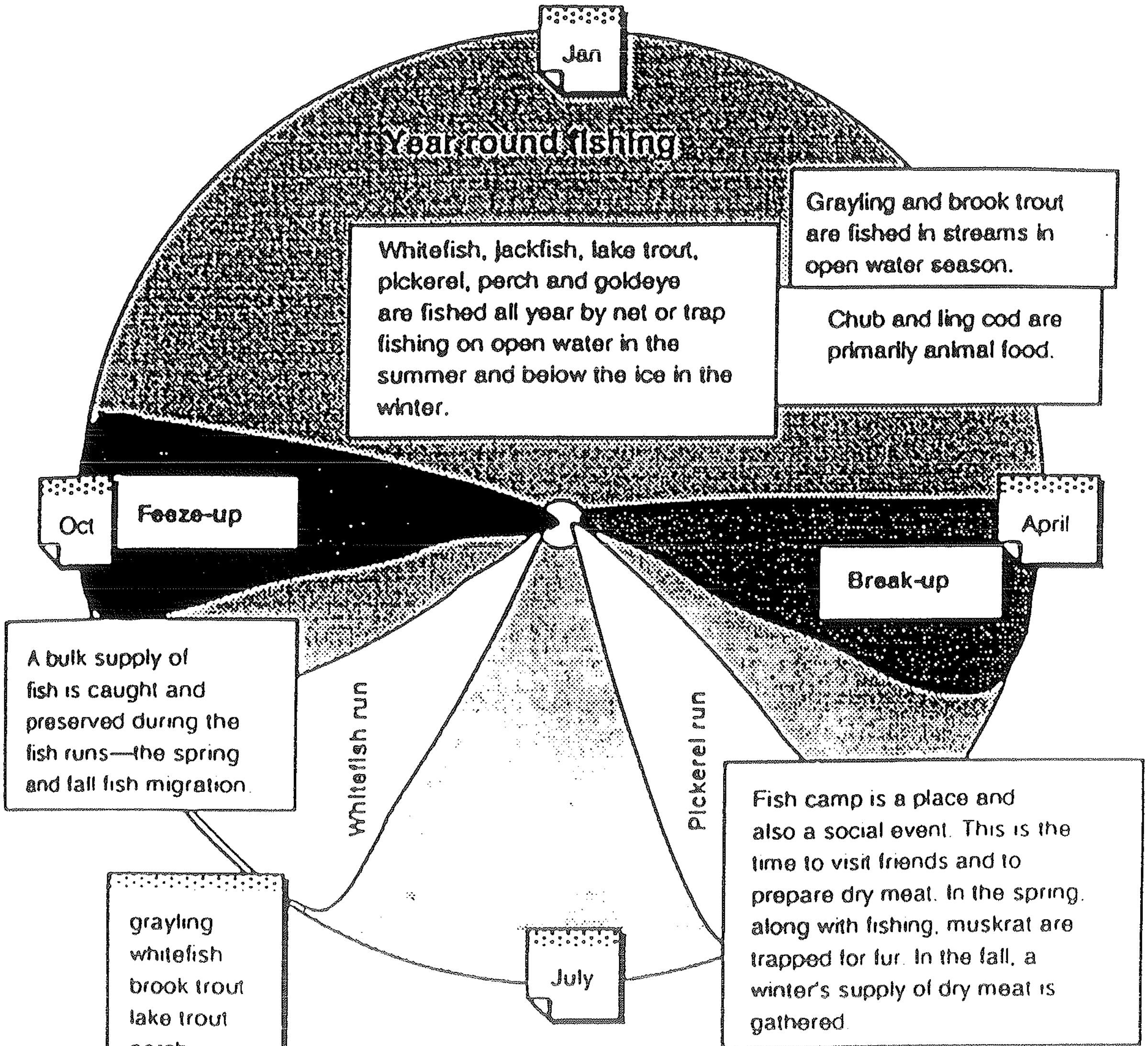
Fort McKay First Nations traditional land use



Big game range throughout the TLUOS area, but not all species are found in every region. Some regions have moose only, or moose and deer only. Woodland caribou range in pockets of the bush, on the west side of the Athabasca River. Barren land caribou are migratory and occasionally migrate to the north fringe of the bush land. Buffalo may free roam freely but they are generally in controlled areas

Seasonal round for harvesting fish

Fort McKay First Nations traditional land use



Fish is an important part of the food supply — fresh, frozen or dry-cured. Fish scale, colored, is used to decorate artifacts and clothing accessories. Fish skin makes a delicate fabric. Fish bone is boiled to render fat. Fish eggs are an ingredient of bannock.

In addition, oil sands development began in the late 1950's and continues to the present day. The developments located in the traditional land use area of the people of Fort McKay. These developments have brought an increase in the non-traditional culture population in the region, a market economy and related goods, increased access to traditional lands and pollution.

In addition to the oil sands developments in the area, commercial forestry operations have been conducted over the traditional land use areas. Logging of coniferous saw timber has occurred for many years. The Alberta Pacific Forest Industry Inc. (AL-PAC) pulp mill and forest management operations were approved in the early 1990's for the utilization of deciduous and coniferous pulp timber. AL-PAC currently holds a large Forest Management Agreement which is superimposed on the traditional land use areas of several aboriginal communities, including Fort McKay.

Logging occurs throughout the entire region on a continuous and sustainable basis. It is carried out by both AL-PAC and Northlands Forest Products Ltd., a coniferous saw timber quota holder. Northlands, during its coniferous logging operations, also removes and stacks deciduous trees for AL-PAC. This is consistent with integrated coniferous and deciduous logging operations in the province, and helps to optimize the utilization of timber resources by improving the cost effectiveness for both operators, while limiting the environmental impacts within and beyond the FMA area.

These logging activities are combining with andupswing in exploration to more clearly define the oil sands ore bodies. This is being done to determine what types of precious minerals might be located in the region. All of these activities are cumulative in nature, and are creating major changes to the environment within which the people of Fort McKay reside , as well as to their traditional life styles.

3.0 REGIONAL TRADITIONAL LAND USE

3.1 Regional Study Area

There are a number of traditional land use areas delineated for regional studies in the available literature The Fort McKay community adheres to the region delineated in the document , "From Where We Stand" (Fort McKay Tribal Administration, 1983). However, more site specific information is available from "There is Still Survival Out There," (Fort McKay First Nation, 1994). and its Birch Mountain/Firebag River Traditional Land Use maps, and the subsequent Syncrude/Suncor Regional Study Area Traditional Knowledge Maps (Fort McKay Environment Services Ltd. 1996). The area delineated for regional study by this project will be based on the document, "There is Still Survival Out There," and the maps contained therein. supplemental information is provided by subsequent studies.

The regional study area topography is generally undulating to rolling, with moderate to steep relief along the river valleys. The terrain and forest cover found within the region are diverse and are representative of a variety of ecotypes found in the boreal forest. Sites can range from mixed wood uplands, to black spruce bogs and open wetlands, which give way to the jack pine covered sand dunes.

Spruce-Aspen forest can be found along the flanks of the Birch Mountains, while giant white spruce and balsam poplar grow on the rich flood plains of the Athabasca River. ("Use of the Proposed Suncor Steepbank Mine Lease Area by Aquatic Mammals and other Fauna" Fort McKay Environment Services Ltd., 1996., and "Baseline Resource Use in the Aurora Mine Environmental Impact Assessment Regional Study Area." Fort McKay Environment Services Ltd. 1996).

3.2. Regional Traditional Land Use

Trails and Cabins

The general region has an extensive trail system that was originally traveled on foot and by dog team . Major trails, many of which still exist, were located adjacent to the Athabasca River, especially on the western bank, from Birch Mountains to the MacKay River. In the Shell Muskeg project area, traditional trails and cabins are to be found along the Athabasca valley, and along the Muskeg River.

Many major trails lead from the Athabasca River to lakes, such as Namur and Moose (Gardiner) Lakes, following river valleys and lake shores.

Cabin sites were important at lakes, such as Namur, Gardiner, Kearl, and Sand lakes, and along river routes, such as the Firebag and the Athabasca Rivers. Favorite sites for cabins were at the confluence of rivers, good fishing areas and lake beaches. Approximately 54 old cabin sites were noted in the regional traditional land use area east and west of the Athabasca River.

Currently these traditional trails are being eliminated at a rapid rate, and are being replaced by seismic lines, temporary roads and trails pushed through the bush by ATVs. Transportation in the bush is now largely carried out by 4X4 pick-up trucks and ATVs from spring to fall. Snow machines and quads provide most of the transportation on the trap lines in the winter. About 61 cabins are thought to currently exist, and are used with relative frequency throughout the region. Use of these cabins may be heavier during certain times of the year than others.

Spiritual and Historical Sites

There are spiritual and historical sites within the region that are of special significance. They are commonly located in areas that were used for camping or meeting during the seasonal travels from resource base to resource base. Though many of the sites go unmarked, some retain their historical markers. Approximately 24 grave sites have been identified in the region.

Sites of historical significance to the Fort McKay community were also identified in the region. These range from fur trading locations to areas of early occupation. Fourteen of these historical sites were included in the traditional land use area, but it is likely that many sites which might have had historical significance, have been forgotten with the passing of time and generations.

Fur Bearing Animals

The animals identified as being of traditional use and significance include beaver, wolf, coyote, marten, lynx, wolverine, weasel, rabbit, fox, bear, otter, skunk, fisher, squirrel, muskrat, and mink. Fur bearers are harvested by trappers. Certain of these, such as beaver, muskrat, lynx squirrel, bear and rabbit, provide meat, while all provide fabric for clothing and trade.

River corridors and lakes were very important in trapping because they provide routes for both animals and people. Occasionally, they provided places for trappers to locate cabins (i.e., at the confluence of most of streams and rivers).

Wolverine are not numerous in the area, though all of the above species can still be trapped throughout the region. Other species such as the major canine and feline predators, fluctuate in accordance with prey numbers (Keith, L. B., et al, University of Wisconsin: Studies on Snowshoe Hare and Ruffed Grouse Population cycles, conducted at the Rochester Biological Station , Rochester, Alberta !966 to 1980's.).

Big Game Animals

At the top of the list of big game animals identified as being of traditional use and significance is the moose. This species is consumed on an almost daily basis by all within the community. Caribou, buffalo, and deer follow moose in order of preference It is noteworthy that, while both species of Caribou are consumed by the various communities in the area, including Fort McKay, almost the entire supply of caribou meat is provided by relatives and friends who live in the NWT. The caribou meat provided to the locals is almost exclusively barren ground caribou taken during their migrations throughout the lower portions of the NWT. During the last two years, only two woodland caribou kills have been recorded in the region both in general vicinity of the Petro-Canada project. The Petro-Canada Lease is far to the west of Shell's Muskeg River Project.

No woodland caribou have been taken on the Shell's Lease 13 (Muskeg River) area in the recent past. Barren ground caribou were observed in the vicinity of what is now the Suncor Steepbank and project, and Project Millennium lease areas in 1958, when a small group moved through what is now the Suncor lease area, down into and through the town of Fort McMurray, and then turned back north (R. Webb. Former Biologist, Alberta Fish and Wildlife Division, Pers. Comm.) They have not returned since in observable numbers.

Free ranging bison (buffalo) are few in number south of Wood Buffalo National Park. Most bison in the region are confined within well defined natural areas, with

the exception of one or two small groups which range south of Lake Athabasca. Bison have also been observed north west of the community of Fort McKay in the Birch Mountain area, and near the Namur Lake and Moose Lake Reserves, but these are only occasional sitings.

White tailed deer have experienced a marked increase in numbers throughout the province during the past 30 years. Mule deer are also on the increase, but are less numerous than White tails. These increases are undoubtedly due to the increase in open areas and edge created by logging and agriculture. Whilst the white tailed deer ranks higher than the Mule deer in order of preference as a food amongst the community members in the area, deer in general are not preferred as a food species .

Moose frequent the Shell Lease area, and two moose were sited near the Shell Lease 13 area site during and October helicopter reconnaissance of the general study area.

Fish

Traditionally harvested fish in the region include goldeye, whitefish, grayling, pickerel, chub, sucker, ling cod, Great Northern pike (jackfish), some lake trout, and perch. Fish were an important part of the food supply. Fish scale was coloured and used to decorate artifacts and clothing accessories . Fish eggs are still very occasionally used as an ingredient in bannock. The majority of fish caught in spring and fall were preserved. The fish harvesting camps were in reality, seasonal gathering spots for both social and food gathering activities. The Muskeg River is still utilized as a source of grayling

It is important to note that members of the community of Fort McKay consider the fish from the Athabasca River to be contaminated, or at least "bad tasting." For this reason, these people acquire their fish from lakes to the north and west of the Athabasca drainage, and the community of Fort McKay.

Birds

The region produces a variety of birds which are used by the locals on a relatively frequent basis. Among these are ducks, loons, geese, swans, grouse, owls, eagles, gulls and cranes. The most frequently used are the three species of grouse resident to the area, followed, in season, by several species of ducks and geese. While a variety of other species of birds are made use of, the frequency of this use is relatively low, being associated with a variety of special occasions where colour and decorative dress are required.

Loon skins are used to make water proof purses or packs. Feathers from the larger birds of prey such as eagles and hawks are still used for decorations and ceremonial dress. Owls, particularly the Great Horned Owl and the Great Grey Owl are still occasionally eaten.

Eggs from ducks and geese are still gathered in the spring by a few of the Fort McKay community members, but this is not an activity on the increase.

A wide range of bird habitat can still be found along the riparian areas and in the wetlands within, and adjacent to the lakes and rivers in the area.

It should be noted at this point that little has been mentioned regarding song birds and other smaller avian species . When asked about these birds, members of the community of Fort McKay interviewed state that, where there once were many song birds in times past, there are now few or none. The people believe that this situation has been brought about by emissions from the oil sands plants.

Trees and Other Plants

White spruce, black spruce, tamarack, balsam fir, jack pine, birch, alder, balsam poplar, aspen and willow were identified as the trees of significant traditional use in the region. A variety of fruits and berries were, and still are, gathered throughout the area in season, and consumed in a number of ways. These comprise the following: Blueberry, various species of cranberries, chokecherry, saskatoon, twisted stalk, rose hips, and occasionally juniper berry, bunch berry and "red willow" berries. The last two species are both dogwoods (i.e., the genus *Cornus*), and the species called "red willow," is in fact red osier dogwood. The inner bark of this red willow is shredded and used as an additive to tobacco. In this for it is called "Kinnickinnick" by the locals from the community. In addition, plants such as rat root, sweet grass, mint, seneca root, muskeg moss and wintergreen were also used traditionally. The Athabasca River corridor, major tributary creeks and rivers, and the lakes were, and still are, areas of importance in the gathering of plant species for consumptive use by the locals.

It should be noted that in a recent food habits study conducted in the community of Fort McKay, Blueberries, cranberries and rat root were identified as the local plants which were the most heavily consumed, and they were consumed by everyone in the community as frequently as possible.

Trees and many other plants were, and still are, used on a year round basis. Fir, pine and spruce were (and still are) used for constructing building, firewood and enclosures. coniferous sap is still occasionally used to make salve and poultices. Seneca root and wintergreen were, and still are, used for treating colds and influenza, as is rat root, the most heavily used of the medicinal plants consumed by the community.

Place Names

Traditional place names often indicate what was found at that site, what the area was used for, and/or what the area was important for from the native perspective. Many of these places are still referred to by their traditional names even though Greater society has formally named them something else (i.e. Cree Burn Lake is still rather adamantly called 'Isadore's Lake" by Fort McKay community members).

Trap Lines

Traditionally, the Fort McKay aboriginal people used the entire region as a source of materials which were traditionally consumed for either food or medicinal purposes. The trap line registration in the 1930's to 1940's , and the subsequent changes in the 1960's forced the people into areas limited by borders. Members of the community are noted as the registered holders of 36 trap lines. These trap lines cover about 2,500 square kilometres, or approximately on third of what these people consider to be their traditional resource use area.

These trap lines are operated by members of the Fort McKay settlement and extend to Namur and Gardener Lakes to the west, north to Poplar point on the Athabasca River, east to the headwaters of the Firebag River, and south to Fort McMurray. Registered trap line numbers 1650, 2172, and 2006 are located on and adjacent to the Shell Muskeg River Project area.

3.3 RESOURCE USE IN THE REGIONAL STUDY AREA

The following information is based on the document, "Baseline Resource Use in the Aurora Mine Environmental Impact Assessment Regional Study Area" (Fort McKay Environment Services ltd., 1996) The information gives further explanation to what uses he Fort McKay community made of the resources available to them in the region.

Trap Lines

Within the regional study area there are as previously stated, 36 trap lines. Most are operated by descendants of the original trap line holders of Fort McKay. The trap lines are rarely operated by one person. A partner arrangement is almost always in place. This method of operation has been and still is being driven by a need to keep the family together, as well as for safety reasons. Trap lines are the locations where the trap line holder and his family and partners hunt, trap and gather for both their own need and for those of the community. In many cases, even today, these trap lines form the basis of the life style to which the trapper, along with his ancestors and his progeny are traditionally and historically tied. Unfortunately, the passing on of the bush craft from old to young is a rapidly diminishing practice. Those who do operate their trap lines, still contribute significantly to the community meat supply.

Forestry

Tree harvesting by the Fort McKay residents for building materials, medicines, firewood, smoking and curing meat and fish, and for spiritual uses, while incidental, is still occasionally carried out. Due to the study area's mixed wood nature, both coniferous and deciduous trees were of use to the community. Coniferous trees were, and still are, of importance to the community and include the following: white spruce, black spruce, jack pine, tamarack, and balsam fir. Deciduous trees include balsam poplar, aspen, paper birch, willow, and alder.

Sap from the two spruce species, jack pine, and balsam fir is still used for a number of purposes including the production of cold medicine. Birch sap has been used to make syrup for generations. Willow bark is still used for tea, which has traditional curative medicinal properties for colds, head aches and stomach problems. Both willow and alder are used to smoke and cure fish and meat. Conifers were used for constructing cabins, while deciduous trees were, and are, used for firewood. Both conifers and deciduous trees have been used to construct furniture for community members.

Berries and Shrubs

Berries and shrubs were and still are, used for food, medicines, ceremonial and spiritual purposes. Some examples of these species include: Huckleberry, blueberry, cranberry, saskatoon, chokecherry, pincherry, raspberry, currant, gooseberry, strawberry, twisted stalk, and rose hips. Plants are eaten raw and are preserved and used for sauces, or in pastries. some are used to make drinks for health and social purposes.

In addition, bearberry (kinnickinnick) [Note: red osier dogwood is also occasionally called "Kinnickinnick"], dogwood (bunchberry), juniper berry and hazelnut were , and continue to be, consumed by the community in small amounts. Bunchberry and juniper berry are used for food flavoring, and have traditional medicinal uses. Hazelnuts, when found, are consumed raw, or roasted.

Herbs

Herbs, including common yarrow, tansy, plantain, mint, common nettle and chamomile, were, and still are, used for food and teas. Common nettle is traditionally used as a cooked green, and to make dye. Tansy (common) was used as a spice to flavour soup and meat, but is used infrequently today.

Other Plants

Moisture tolerant plants found in the wetlands were also of traditional use. Plants such as the cattail, bulrush, rat root, labrador tea and moss were, and still are, occasionally used for food and medicine.

Roots of cattails and bulrushes have been consumed by aboriginal people for centuries as a source of carbohydrate. Flour made from cattail root has been identified as an excellent material from which to make bread for consumption by those people who are allergic to certain types of sugars. It is unfortunate that these plants also have the ability to accumulate large quantities of trace and heavy metals from the medium within which they reside. Rat root is used as an all purpose medicine, treating such ailments as head aches and tooth aches. Labrador tea is used as a medicine and a social drink. Mosses are still occasionally dried and used as diaper material, though this practice is becoming less frequent.

Big Game

The consumption of animals present in the region has been part of the aboriginal people's life style and is still very much a part of this life style today. The development of the area, however, is changing the species composition of big game in the region. Black bears are numerous, but caribou are only occasionally observed. Moose remain the big game species preferred by the people, and are still relatively abundant. The recent fires which ravaged the region, have undoubtedly created a situation which will favour an increase in moose numbers, which will be brought about by the new and voluminous food supply. Unfortunately, if the additional access provided by the loggers and the oil exploration companies is capitalized on by moose hunters, the moose will be unable to take advantage of this massive new food source. In spite of this, however, moose still supplies most of the meat required by the people of Fort McKay, and the other surrounding communities. In addition, deer have become more numerous in the area. they are not as readily sought after as moose, but are taken when the opportunity presents itself. While lower on the preference list, deer still provide a certain amount of protein and are not bypassed as a food source.

Fur bearers

The hides, meat and other portions of furbearing animals trapped by community members were, and still are, part of the traditional lifestyle of the community. Muskrat and beaver are regarded as a diet staple by trappers and their families. Tails are consumed in addition to the flesh. Oils and musk glands are used to make perfumes.

Fisher, marten and wolverine are still trapped, though their numbers fluctuate. Otter and mink are also taken in accordance with their numbers, and with price of their fur. Canines are hunted when the opportunity presents itself. The price of their hides determine the trapping effort. Lynx are always a well regarded fur. It is also occasionally eaten on the trap line, and is regarded as a high quality flesh by those who have eaten it. The success of the trapper in trapping lynx, coyote and fox is to a large extent, dependent on the status of the population of Snowshoe hares in the area. The predatory canines and felines are invariably closely linked in numbers to the level of the hare population.

Snowshoe hares (rabbits) are a common prey species and are eaten by virtually all predators, avian or terrestrial. Rabbit is considered a diet staple by the people of Fort McKay ("Survey of the Consumptive Use of Traditional Resources by the Community of Fort McKay" Fort McKay Environment Services Ltd. for Syncrude Canada Limited, May 1997), and their hides are used for inner garments as well as blankets. They are taken opportunistically by trappers and hunters whenever they are encountered. Even women and children gathering berries will set snares for hares to be used for camp meat while they are picking berries.

Birds

The Athabasca Valley and larger lakes in the region are summer and (in the case of resident birds) winter habitat for a variety of birds. Waterfowl are present and hunted in both spring and fall. Eggs are still occasionally used for food, though the practice of taking eggs from duck nests in the spring is slowly disappearing . A variety of ducks, including mallards, several species of teal, gadwalls, pntails, baldpates, and a number of divers such as the common goldeneye, are taken during the spring and fall migrations. Geese, including Canada geese, snow geese, and white fronted geese, are also taken during spring and fall. Occasionally, the locals will travel all the way to the Athabasca Delta to hunt geese in a more concentrated fashion. Swans and Sand hill cranes are hunted for food, as well, but efforts to hunt them are less concentrated, and they are more likely to fall into the bag only if the opportunity presents itself while hunting ducks or geese. Feathers from most of the above species are used for winter clothing and bedding.

Upland game birds including ptarmigan, Ruffed Grouse, Sharp tailed Grouse and Spruce Grouse all are resident in the traditional resource use area used by the community of Fort McKay. Grouse, collectively called, " chicken" by the people from the communities in the area, are the birds most consumed by the people of Fort McKay (see Survey of Consumptive Uses of Traditional Resources by the Community of Fort McKay, referred to previously). These birds, like the Snowshoe hare, are taken by trappers, hunters, berry pickers and kids learning to hunt and trap, whenever and wherever they can be found. After moose and hares, grouse are most heavily preyed upon by the people in the area.

The Willow ptarmigan is generally a winter visitor to the region, and while it is not refused as a food source, it is taken with much less frequency than the local grouse species.

Fish

Fish were traditionally used as a food source and feed for dogs. While dogs are rarely used as winter transport in this day and age, many of the older members of the community of Fort McKay still consume large numbers of fish. Traditionally, the bulk of the fish consumed were taken from the Athabasca River. Particularly popular as a summer fishing site was Tar Island, currently the site of the Suncor Tailings pond. In interviews with several of the Elders. it was learned that tens of thousands of fish were caught at this site during the summer. These fish were smoked, dried, and salted to prepare for the winter months when freeze-up and heavy ice conditions interfered with fishing.

White fish were, and still are, preferred, along with the Great Northern Pike, locally called, "jackfish." Lake trout which is actually a char) and walleye (locally called "pickerel") were caught in Namur and Gardiner Lakes.

The establishment of the Suncor tailings pond on Tar Island in the 1960's had a strong negative influence on the taking of fish from the Athabasca River system, but the Fort McKay people never completely stopped fishing in the river until the 1980's. Since then, data has been produced indicating that the fish in the river do indeed contain a number of contaminants including mercury and "tetrachloroguiacols" (a hydrocarbon contaminant derived from , and fingerprinting the pulp and paper industry). Thus, while one or two locals still fish in the river, health warnings of contamination in fish from the Athabasca River system issued by Alberta Fish and Wildlife , have resulted in a heavier use of fish from Namur and Moose (Gardener) Lakes, located to the north and west of the community of Fort McKay. This is unfortunately bad news for the fishery in these lakes.. These lakes contain large numbers of fish, many of which are of trophy size. These lakes are not overly productive because of their northern locations, and it takes many years to produce a sexually mature fish. Thus, spawning in these lakes does not occur until fish reach a relatively old age. They are thus exposed to predation for many years before they spawn, and must run the gauntlet merely to reach spawning age. It is very likely that these lakes will suffer from over-fishing in the near future, unless drastic and timely steps are taken to limit the harvest of spawning age fish.

3.4 CONSUMPTION OF TRADITIONAL RESOURCES

Sixty community members were interviewed regarding consumption of resources from the traditional resource use area for the year of 1996, in "A Survey of the Consumptive Use of Traditional Resources in the Community of Fort McKay " (Fort McKay Environment Services Ltd. , 1997, for Syncrude Canada Limited.). This study was carried out to determine the identity of which species of wild flora and fauna located in the region were still being consumed by the members of the community, and which of those were consumed in the largest amounts, and by the most people. The results will be utilized to determine what floral and faunal tissues will be sampled for trace and heavy metals, and PAH's (Polycyclic Aromatic Hydrocarbons).

The study does, indeed, illustrate that traditional resources in the form of plants and animals are still consumed in quantities, and it clearly demonstrates the species preferred for consumption by the community members interviewed.

Mammals

Virtually all of the community members interviewed state that they ate moose almost every day, and that every one they knew and were related to also ate moose almost every day. The median number of times a person ate moose was 90 times, but some actually stated that they ate moose as frequently as 300 days per year.

From a mammalian perspective, rabbits (Snowshoe hare) were the next highest in consumption. Forty five of the 60 people interviewed had consumed Snowshoe hare during 1996. The bulk of the interviewed community members indicated they ate hare as many as 150 times per year. Snowshoe hares are taken at every opportunity, by all members of the community.

Next in this order of preference was beaver, consumption being approximately half of that indicated for moose and Snowshoe hare. Notably, those on the trap lines and the older members of the community appeared to be most likely to have a preference for beaver flesh or beaver tail, considered to be a true delicacy by a number of the Elders interviewed.

Deer species were consumed, but did not occupy a favoured position in the gourmet line-up. White-tailed deer, being more abundant than Mule deer in the traditional land use area, were also taken more often than Mule deer, but neither appeared high on the list as a meat source preferred by members of the community. During the interviews, less than 1/3 of the people who responded, stated that they ate deer. Most of those interviewed indicated that they would rather eat moose, or even "meat bought from Safeway" before they ate deer meat.

Less than 1/4 of those interviewed indicated that they ate muskrat when in season, and those who responded positively were invariably trappers, or their immediate family members. Thus, while 3/4 of those interviewed did not consume muskrat, most of the trappers indicated that, while it was not actually preferred, it was indeed tasty fare, and they did not waste it when it was part or the catch.

Finally, Wood bison (buffalo) were not considered a diet staple by those interviewed during the food habits study. That which was eaten resulted from the required disposal of a Syncrude/Fort McKay Wood bison injured in the annual round-up. It was disposed of, butchered, and distributed to members of the community of Fort McKay. As of January, 1998, between 60 and 70 Wood bison were shipped south for auction as part of the Syncrude/Fort McKay Wood bison management plan. An additional seven wood bison have been allocated to Fort McKay First Nation for use as the Band so desires.

It should be noted that in the case of Wood Bison, it is likely that in due course, when the Syncrude/Fort McKay herd reaches a size where it exceeds the capacity of the pasture, more such slaughters and sales will occur, and a great deal more Wood bison flesh will be consumed. It is therefore likely to assume a higher position in the amount of meat it supplies, as well as in the area of taste preference.

Fish

About 3/4 of the community regularly consumes fish. Those most frequently eaten are whitefish and jackfish (Great Northern Pike).

Three quarters of those interviewed stated that they consumed whitefish throughout the year, and just over half stated that they ate jackfish throughout the year. The majority of these fish were harvested from Namur and Gardiner (Moose) Lakes. The median number for consumption was 12 to 13 times per year.

Birds

Both migratory and resident birds are consumed by community members. Eggs, particularly those of ducks during spring nesting, are still occasionally collected and consumed, but this practice is no longer carried on to any significant extent. Predatory birds such as the larger owl species are only taken when the opportunity presents itself. These species are consumed by a few members of the community, who state that a "good stuffed, roasted owl is as good tasting as any roast stuffed turkey." This may indeed, be true, but most other community members, particularly the younger of these, do not appear to have developed a taste for stuffed roasted owl.

Ducks, generically, were consumed by 46 out of the 60 people interviewed. Ducks, (particularly dabbling ducks) during a brief period in the spring and fall, will comprise the majority of bird protein consumed by community members during this period. The consumption levels ranged between one, and one hundred times per person, per year.

Geese (Canada, Snow, and White fronted geese) were consumed by about half of those interviewed. This consumption, like that of the ducks, occurred to a large extent during periods of migration in the spring and fall. Consumption levels among the individuals who consume geese and were interviewed, ranged from one to fifty times per person per year.

Grouse (the three local species being collectively called "chicken" by the locals) were consumed throughout the year by approximately 2/3 of those interviewed, thus making this group the third highest source of wild protein utilized by the community (moose and snowshoe hares being first and second, respectively). They are resident birds and like hares, are taken when and where the opportunity presents itself.

Ptarmigan were infrequently consumed. This is undoubtedly because the opportunity to take these birds only presents itself during the winter months in the traditional resource use area of the members of the community of Fort McKay. This may also be a reflection of their ability to hide well in the snow, and/ or the weather conditions which are present when they pass through the area. Ptarmigan tend to move from north to south. This movement, however, is rather more of a change of temporary residence within a very large "home range," than a true migration.

Swans are taken and eaten, but only on rare occasions. This is likely because of their lower numbers, their migratory patterns, and the fact that swans which might nest in the traditional resource use area of the community are very small in number compared to those which migrate to Arctic nesting areas beyond the North West Territorial border.

Plants and Plant Products

The three species consumed most frequently by the community members interviewed were blueberry, cranberry, and ratroot. Mint was also indicated to be a high use plant. Most of the other plants were taken in lesser amounts.

Blueberries are eaten by all who were surveyed, and these people consume blueberries wherever, and whenever they are available. These berries are picked locally, but a number of those interviewed indicated that they have changed their berry picking locations and now travel hundreds of kilometres to find berries that are not "covered with white powder and black specks." They have sought out locations for berries that are well away fro the industrial sites. Unfortunately, a number of the Elders who cannot drive, find it difficult to travel to these other remote (and often secret) locations, and so, are resigned to picking berries close to home, and unfortunately, within range of the plumes of the currently operating plant sites.

Cranberries were in fact, the very species preferred by those interviewed, but this past year was apparently a bad year for cranberries, and there were few to be found. To the members of the community, the term, "cranberry" includes both high bush and bog cranberries. Cranberries are eaten at every opportunity extensively throughout the year. When they are numerous, they are preserved as sauces, jams, jellies, and are frozen and used in this fashion until they either run out, or the next berry season arrives.

Rat root is also considered a high use plant. It is a powerful medicinal root, and while its use as a cure-all is extensive, the amounts used are tiny because of its bitter taste. A single person using rat root on a daily or weekly basis might only use two cups of this plant during a whole year.

Mint, chokecherry, saskatoon, rose hips and other traditionally used plants are eaten or used to make infusions for either health drinks or for pleasure. The availability of saskatoons and chokecherry dictate, to a large extent, their annual consumption.

4.0 SHELL MUSKEG RIVER OIL SANDS MINING PROJECT:

4.1 Project Description and Study Area:

Shell is embarking on a major oil sands open pit mining operation which will take place in the north half of Township 94, Range 10, and the west half of Range 9; and the south half of Township 95, Range 10, and the west half of range 9,West of the 4th meridian This area is located on the east side of the Athabasca River, immediately south of the current Syncrude Aurora mine expansion area

The entire project area is located north and east of the community of Fort McKay

The drainage pattern through the study area is generally from north east to south west, with the Muskeg River flowing in this direction immediately south and east of the projected mining area. Immediately to the north of Lease 13, and now located within the Syncrude Aurora mine lease, is the former Shell ALSANDS lease. The ALSANDS lease was dewatered, and cleared, but the surface layers of were not removed before the project was shelved. The results were the subject of preliminary studies during the summer of 1997.

4.2. Traditional Trails and Cabins:

The trail systems and cabin locations are associated with the river and stream drainages located in this area (see Traditional Knowledge Survey map) A number of cabins, both functional and abandonned, are located within the lease area, and numerous cabins are located on the leases and trap lines adjacent to the Shell lease. Trappers in the area have traditionally used the trails along the Muskeg River to achieve access to their trap lines. A number of cabin sites are located along the Muskeg, and further to the east, along the shores of Kearl lake.

4.3 Trap Lines and Trappers:

In the Study Area selected for the Shell Muskeg River Project there are three trap lines which will be directly affected by the actual mining operation. These trap lines are registered to Raymond Boucher (Number 1650), Alice Boucher (Number 2006), and Mary Tourangeau (Number 2172). All of these trap lines are and have already been, affected by the increase in exploratory drilling activities, which are currently increasing at a rapid rate. The outcome of the actual mining action will actually remove a significant area from the three trap lines involved. This area will amount to the better part of a whole township of land. It is safe to say that the productivity of the areas which will be removed from these trap lines by the actual mine sites will be zero, from the trappers' perspective. The cumulative effects of all of the exploration and encroachment on the remaining portions of these trap lines will have a major effect on the productivity of the trappers and, particularly, on the life styles of them and their families.

4.4 Status of Fish and Wildlife in the Project Study Area:

Discussions with the a number of trappers operating in the general area of the Two mine expansion projects (Syncrude Aurora, and Suncor Millennium), and the Shell Muskeg River Project, resulted in the following observations on the status of fish and wildlife in the area. (The following are direct quotes from "The Community of Fort McKay Traditional Uses of The Renewable Resources on the Suncor Steepbank Mine site" Fort McKay Environment Services Ltd., Jan., 1996, Syncrude Aurora Traditional Resource Use Study, 1996; and the Traditional Food Habits Study of the Community of Fort McKay, 1997). Interviews of Fort McKay community members were held to acquire information on the above areas, and the studies covered the Shell Lease 13 (Muskeg River) area in detail. The following information was derived from the interviews of the trappers in the general area.

"Fur bearers in general are spotty in this area."

Lynx: "The high in lynx numbers (in the study area) last occurred in 1982/83 (about the same time as the peak of the rabbit (Snowshoe hare)populations.

Others, such as fisher, marten, mink and otter, have been low for some time. Otter and mink appear to be coming back. Weasels have increased in number over the past year or two. This increase occurred about the same time as the increase in grouse and ptarmigan.

Muskrats and beaver are not numerous in the study area, and those present are generally found in the rivers.

"Moose and White tailed deer are numerous in the areas covered by the trap lines." Trappers also saw Mule deer in the area on the east side of the Clear water River. The trappers and one of the councilors stated that (barren ground) caribou were last seen in the area in 1958 as they migrated past Fort McMurray To accomplish this , they would have had to pass through the study area.

"There are still lots of Black bears in the study area, but nobody kills them for food anymore, because "they all eat garbage and their meat tastes bad. They are poached a lot by people who sell bear paws and gall bladders." "There was Grizzly sign in the Saline Lake area (just to the north of the study area) in 1990, but neither grizzly , nor tracks have been seen since."

Chicken (upland game birds, all species of grouse) are present in fairly large numbers on the study area. There are a lot of Sharp tailed and Ruffed Grouse. In the winter, ptarmigan migrate into the area (this winter they were particularly numerous). Trapper Julian Powder believes that "the colder the winter, the more ptarmigan come to the area."

"The bush is much quieter today than 15 years ago in the study area, because there are not as many songbirds."

Magpies have moved into Fort McKay. They were never present until just a few years ago. Owls are scarce. Crows and Ravens are increasing because they feed on garbage, and the amount of garbage is increasing all the time."

"There are still a lot of ducks, especially during spring migrations, but a lot of water which once produced many ducks during the summer no longer can support ducks."

Occasionally in the spring, in the Saline lake area, coot and duck eggs are still harvested and eaten."

"Cranes migrate through the study area during the spring and fall. Blue herons moved into the area in 1970. snow and Canada gees migrate through during both spring and fall."

"Fish in the Athabasca River system are regarded as unfit to eat. In the Steepbank River there are still grayling to be found and occasionally caught. In Johnson Lake, there used to be pike, but this is no longer the case as of 5 years ago."

All trappers believe that "the Athabasca River is polluted." They, along with most of the other Elders in the community believe that the river is also much lower, muddier, and tougher to travel because of the increase in sand bars in recent years.

:"The land was much dryer until 5 years ago. At that time, changes occurred which made the area wetter. changes to the land surface are also on the increase, and the trap lines are "wasting away."

The trappers believe that "it is warmer overall. It is also windier and weather is generally more unstable now than in the past."

The trappers believe that more trees are suffering from disease. They feel that the death of trees in certain areas is caused in part by a localized lack of water. probably due to accidental drainage because of the clearing of cutlines.

The trappers, and almost all of the other Elders interviewed made it very clear that "the trap line was, and still is, the most important item affecting and directing their entire life style." The three trappers on the Shell lease, and the other Elders have trapper for most of their adult lives.

4.5 Traditional Use of Plant Resources on the Shell Muskeg River Project Area

Over the centuries, the activities of the people in filling their daily needs for food, medicines and shelter, came together to make up the ways of the Aboriginal people of the area. These ways have evolved into what is now called "Traditional Land use." The aboriginals call this life style "Sagow Pematosowin."

4.6 Traditional use of Plants on the Land:

In times past, the number of trees used on an annual basis was much lower than it is today, but the use of these trees was important to the people. They used certain trees for medicines, (balsam fir) firewood, for smoking and curing fish and game, building materials for cabins and teepees.

Both evergreens and broad leafed trees have traditionally been important to the people of Fort McKay. For instance, several Elders said that sap from balsam fir and pines was, and still is , used for a variety of ailments including colds and bronchitis.

Birch sap has been traditionally used to make a syrup like maple syrup (Elders interviews). willow bark has traditionally been boiled and consumed as a tea which is still used to cure headaches, colds, and stomach problems. Willow and alder continue to be used for smoking and curing of fish, and meat.

4.7 Traditional use of Berries, Shrubs, and Wet Area Plants:

At least 30 different berries, shrubs and wet area plants are traditionally picked and consumed in the study area. Most of these have been traditionally used for food, but some of them serve medicinal, ceremonial or spiritual purposes.

Most berries picked and eaten are considered "sweet." This means that they are eaten raw, sometimes served cooked in pastries or sauces, or made into jams or preserves. Other berries such as juniper or kinnickinnick are used in other ways, such as for tobacco, or as a medicine for colds or chest problems.

The leaves and roots of a number of other herbs and shrubs are also harvested from the study area for a variety of uses, either as a diet supplement or for medicinal purposes. Among these are the various mints, cattails, bulrushes and rat root.

Blueberry roots are occasionally used to make an infusion which was (and still is) used to treat diabetes. (Fred Bourque, Anzac, Alberta: Pers. Comm.)

5. ELDERS OBSERVATIONS ON THE TRAP LINES

Note; the observations to follow include those of the trappers from the Study area. therefore the following information applies to the study area.

The trappers are unhappy with the treatment they receive from the Alberta Trappers Compensation Board (ATCB) in regard to compensation for damages to their trap lines. One of the trappers from the area states that his cabin and trap lines, including his traps and sets, have been damaged several times. He has already lost production from a large portion of his trap line due to logging and seismic work. The additional disturbance and increase in the rate of exploration , which together, have augmented accumulation of issues that disrupt the activities on his trap line has created a major concern for the health of his trap line, and for the survival of his life style.

He says his treatment at the hands of the ATCB and the amount of money he received for damages was an insult. He stated that even thought there was an estimated several thousand dollars worth of damage and theft, "it (the money he finally received) did not cover the cost of even one (1) gun."

Members of the community are concerned because the plants traditionally picked from this area are now covered with a grey and black dust. Elders interviewed believe that this dust comes from the smoke stacks of the two oil sands facilities already in operation, and if they eat these plants they might get sick. For this reason, many of the Fort McKay community members no longer pick berries and plants in the Study Area.

Up until about 30 years ago, the people of Fort McKay used fish to feed themselves and their dogs for much of the year. Most of these fish were caught in the Athabasca River between the Shell Muskeg River Project area, and Suncor's tailings pond, located at what was once a summer camp site called Tar Island. Elders interviewed said that thousands of fish were caught and dried for the winter food supply for both people and dog teams. This annual fishing event which took place undisturbed for centuries at this site, ended when GCOS began its operation and covered Tar Island, their traditional meeting place, with a tailings pond. Fishing tapered off during the following years, and by the 1980's virtually disappeared as a sustenance fishery.

There are no lake fisheries on the proposed Shell Muskeg River mine sites. River fisheries are still present in the Muskeg River for grayling, but it is not heavily used by the locals.

6. DISCUSSION:

Times and lifestyles are changing, and the changes are coming faster and faster. the lands and wildlife within the study area have been altered considerably over the past year or two, and will shortly experience a complete metamorphosis, but it will be a reverse, and rather than changing from a relatively unattractive larva to a beautiful butterfly, the change will be from the still recognizable boreal forest to a large black hole in the earth which for many years will produce no appreciable floral or faunal growth at all.

Resource companies continue to explore on and adjacent to the study area. Soon they will begin clearing, draining, channeling and mining. More cutlines will appear, along with a permanent road or two. permanent power line rights-of-way and the powerlines themselves will appear, along with pipelines, and all of the maintenance crews required to keep all of the above running along at optimum levels. The effects on the two trappers in the study area will not only be cumulative, the rates of increase of these effects will be almost exponential. It is unnecessary to dwell on how these changes will effect the fish, birds, and wildlife which up till now have made use of the area.

The study area is only a small part of a very large amount of land which will experience this ever increasing rate of change. It is incumbent upon the Lease holder in this situation to ensure that all efforts are made to reduce the various environmental, social and economical downside of their project to the best of their abilities, and to ensure that they at least comply with the Monitoring Authorities so that this does indeed occur.

In consideration of the two trappers, who will lose a major portion of the actual physical parameters of their trap lines, a company like Suncor with its massive cash flow, income and reserves can ill afford not to look after these two trap line holders in a generous fashion.

7. CONCLUSIONS:

It can be concluded that exploration and testing on the Shell Muskeg River Mine site are already having a strong negative influence on certain members of the community of Fort McKay, notably those individuals who operate the trap lines in the area soon to be mined.

It can also be concluded that major changes will occur to the surface environment within the confines of these mining sites, as well as to the adjacent areas. The physical changes will be accompanied by an increase in access to the surrounding areas, and this increase in access will promote an increase in general disruption, noise disturbance and an increase in vandalism and theft on the trap lines in question and those in the adjacent areas. (It should be noted that theft and vandalism on the trap lines has already become a problem because of this increased access).

It can, moreover, be concluded that these changes will be augmented by more exploration within the Shell holdings to the east of the proposd mine site, and in the adjacent lease areas, and so **it can therefore be concluded that** these changes will be cumulative.

From the above, it can be concluded that the effects of these disturbances on the renewable resource base on and adjacent to the Shell project area will be real, long term, and from the perspective of the Fort McKay community members, singularly negative.

IF! -the Lease Holders and the community of Fort McKay can reach a consensus on the Trappers Compensation Policy proposed and approved by the community, its implementation will offset the destructive forces imposed upon those trappers whose trap lines are involved, along with their families, and those of their partners. Unfortunately, this only accommodates a small number of the community members who will be negatively affected by the dramatic alteration in the renewable resource base upon which they have depended upon for their livelihood to a greater or lesser extent for generations.

It is therefore recommended that Shell be prepared to evaluate the Community's Trapper Compensation Policy Proposal carefully, and be prepared to compensate the people operating the trap lines affected by its mining operation in a fair, and even generous manner. There are after all, only three trap lines involved, along with the attendant individuals and their families.. Their fair compensation cannot possible be of major financial concern, even if this compensation is for a relatively lengthy time period.

It is further recommended that Shell, along with its immediately adjacent Lease Holding neighbours, be prepared to investigate the cumulative effects of their projects collectively on the community of Fort McKay and all of its members. This cannot be accomplished by evaluating the project's cumulative effects from a proponent's perspective . It must be evaluated from the Recipient's perspective, that is from the community's point of view.

It is also recommended that Shell employ these trappers to monitor changes to the environment and to their trap lines. Common Sense indicates that this monitoring exercise be carried out beyond the boundaries of the actual disturbance areas within which the mining will occur. These individuals, have a strong vested interest in the welfare of the environment and the lands within which they trap. They are observant, and make excellent observers. They are able to detect subtle changes to the environment within which they operate because these changes may have a major influence on the flora and fauna from which they still derive much, if not all, of their living, and upon which their lifestyle has been built.

APPENDIX A LITERATURE CITED:

-"Alberta Forest Conservation Strategy: Draft" Oct. 1995 Alberta Dept. of Environmental Protection, Forest Conservation Strategy Steering Committee (87 pp.)

-"Aboriginal Perspectives on Forest Conservation" June, 1995 "A Report of the Aboriginal Working Group of the Alberta Forest Conservation Strategy," Alberta Department of Environmental Protection. (31 pp.)

-"A Survey of Consumptive Use of Traditional Resources in the community of Fort McKay" Fort McKay Environment Services ltd. 1997

-Alberta Fish and wildlife Service, September 1995: Fur Sale Records for Map Sheet #74 D. For 1977 to 1993

-"Baseline Resource Use in the Aurora Mine Environmental Impact Assessment Regional Study Area" Fort McKay Environment Services Ltd. 1996

-Fort McKay Environment Services Ltd. "Survey of Aquatic Mammals in the Suncor Steepbank Mine Study Area." December, 1995

-Fort McKay Environment Services Ltd. "Survey of Aquatic Mammals in the Syncrude Canada Limited Aurora Mine Environmental Impact Assessment Study Area." December, 1995

"Churchill-Reindeer Environmental Impact Study Area Survy Guide: Topic Areas" Provided by Golder & Associates Inc., Calgary, Alberta, July 24, 1992. (19 pp.)

-"Fish and Wildlife Policy For Alberta: October, 1982." Government of Alberta (24 pp.)

-Fort McKay Environment Services Ltd. "Fort McKay Traditional Ecological Knowledge Data Base Questionnaire and Interviews." December 1995 (Internal Document)

-Fort McKay First Nation:" There is Still Survival Out There." October 1994 (130 pp.)

-Fort McKay Tribal Administration: "From Where We Stand" 1983

"Fort McMurray - Athabasca Oil Sands Sub Regional Integrated Resource Plan: Draft: Alberta Department of Environmental Protection. October 1995 (88 pp.)

-Keith, L.B., et al., Univ of Wisconsin: Studies of Snowshoe hare/Ruffed grouse Population Cycles, conduected at the Rochester Biological Station, Rochester, Alberta (1966 to 1980s)

-Reid, Donald G, Stephen M. Herrero, and Thomas E. Code: "River Otters as agents of Water Loss From Beaver Ponds" J. Mamm. 69(1): 100 - 107, 1988

-Rudolph, R.C., M.M. Oleskiw and R.A. Stuart. 1984. "Climatological Analysis of Recent Data From the Athabasca Oil Sands Area." Prepared for the Alberta Oil Sands Environmental Research Program by Intera Environmental Consultants Ltd., Edmonton, Alberta: Research Management Division. AOSERP Report 130, (199 pp.)

- Smith, S.B., Environmental Consultants Ltd. "Resources of the Athabasca River Basin." March 1982 (16 pp.)

-Strong, W.L. and K.R. Leggat, 1981. " Ecoregions of Alberta." ENR Technical Report T/4, Alberta Energy and Natural Resources, Edmonton, Alberta (64 pp.)

Pers. Comm: K. Schmidt, Fish and Wildlife Officer, Ft. McMurray District, October 1995: Fish and Wildlife Use in the Steepbank Mine .

Pers. Comm. M. Grandjambe, Chief, Fort McKay First Nation: Subject: Harvesting of Duck and Coot eggs for food

Pers. Comm: D. Huberdaux, Forest Supt. Alberta Forestry, Fort McMurray Region: November 1995. Future Logging in Suncor Steepbank and Syncrude Aurora Proposed Mine Expansion Areas.

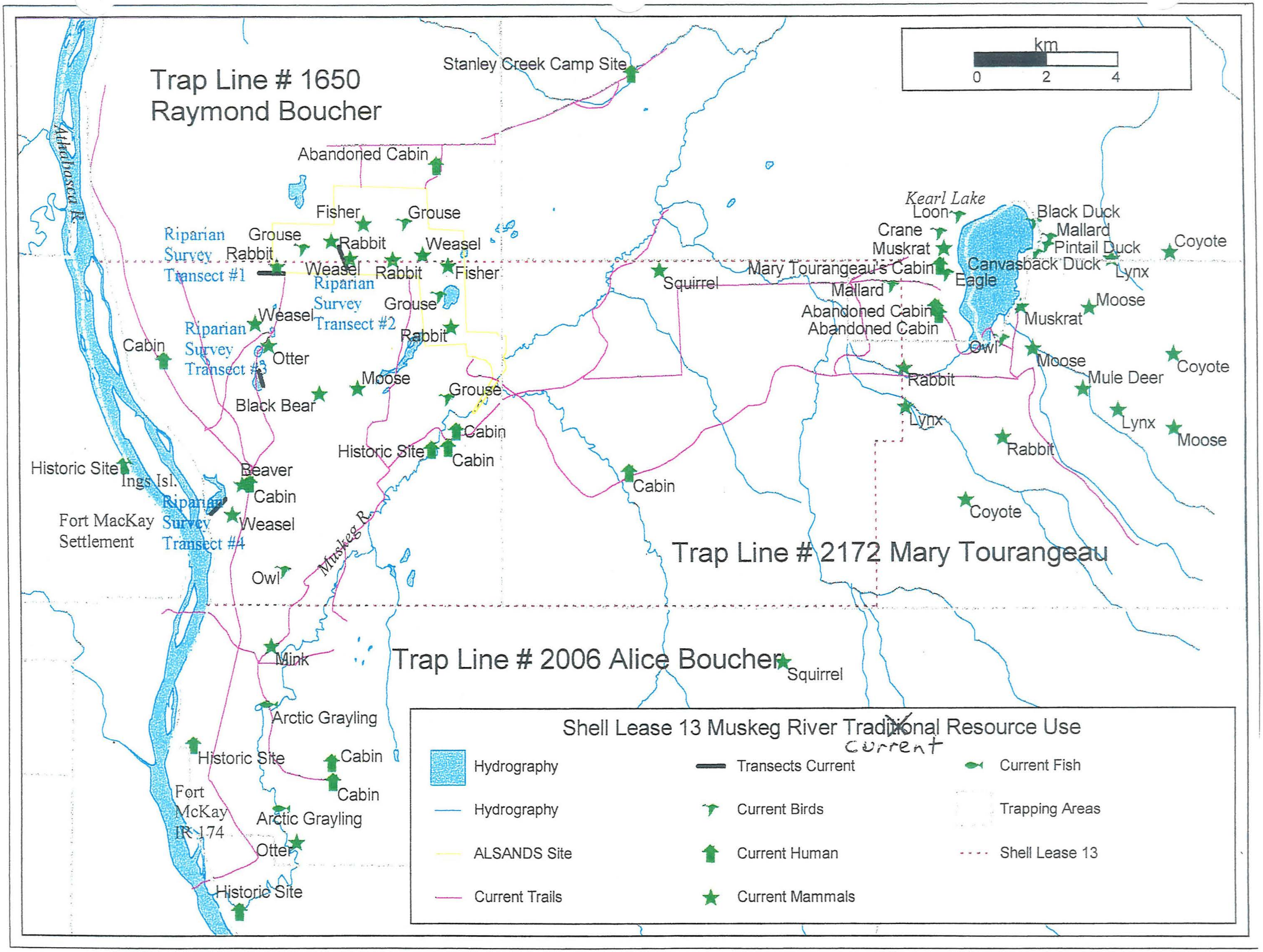
Pers. Comm: F. Bourque, Trapper, Anzac, Alberta, November, 1992: Use of Blueberry root boiled as a drink for Diabetes.

Pers. Comm: R. Arthur, District Forester, Fort McMurray District: November, 1995, Maps and discussion of Logging in the ALPAC FMA.

Pers Comm. R. Webb, Former Biologist, Alberta Fish and wildlife Div. Subject: Barren Ground Caribou Migration through the Regional Study Area.

APPENDIX B.

MAPS:
SHELL MUSKEG RIVER TRADITIONAL KNOWLEDGE SURVEY



Trap Line # 1650 Raymond Boucher
Trap Line # 2172 Mary Tourangeau
Trap Line # 2006 Alice Boucher
km
0 2 4
Stanley Creek Camp Site
Abandoned Cabin
Athabasca R.
Kearl Lake
Muskeg R.
Riparian Survey Transect #1
Riparian Survey Transect #2
Riparian Survey Transect #3
Riparian Survey Transect #4
Fisher
Grouse
Rabbit
Weasel
Otter
Moose
Black Bear
Cabin
Historic Site
Ings Isl.
Beaver
Fort MacKay Settlement
Owl
Squirrel
Mary Tourangeau's Cabin
Mallard
Abandoned Cabin
Loon
Crane
Muskrat
Black Duck
Pintail Duck
Canvasback Duck
Eagle
Lynx
Coyote
Mule Deer
Mink
Arctic Grayling
Fort McKay IR 174
Shell Lease 13 Muskeg River Trad~~itional~~ Resource Use
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ALSANDS Site
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Transects Current
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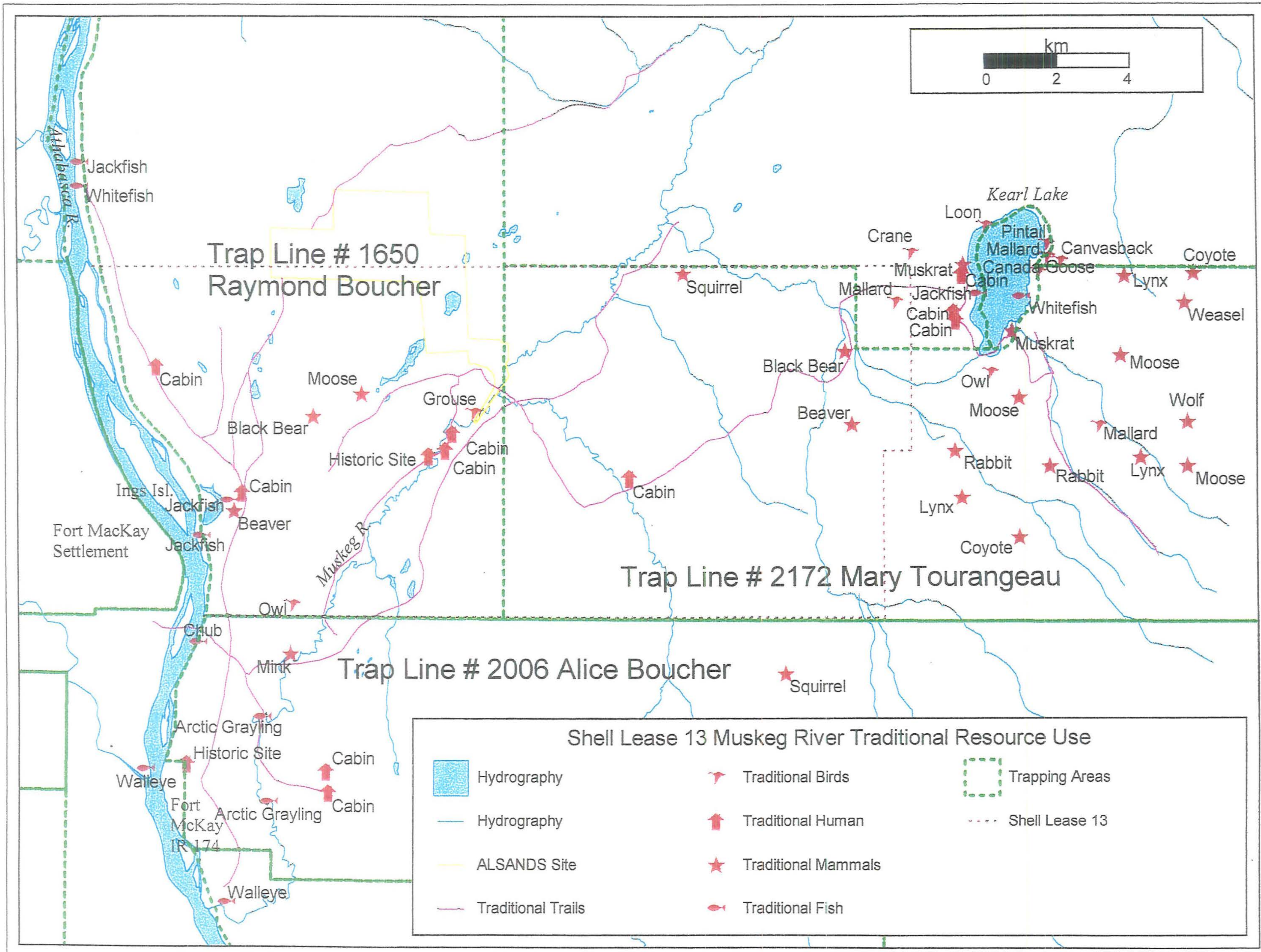
Current Fish
Trapping Areas
Shell Lease 13



km
0
2
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Kearl Lake
Athabasca R.
Muskeg R.
Trap Line # 1650
Raymond Boucher
Trap Line # 2172 Mary Tourangeau
Trap Line # 2006 Alice Boucher
Fort MacKay
Settlement
Ings Isl.
Fort
McKay
IR 174
Jackfish
Whitefish
Cabin
Black Bear
Moose
Grouse
Historic Site
Cabin
Cabin
Jackfish
Beaver
Owl
Chub
Mink
Arctic Grayling
Historic Site
Walleye
Arctic Grayling
Cabin
Cabin
Walleye
Squirrel
Cabin
Loon
Crane
Muskrat
Mallard
Jackfish
Cabin
Cabin
Cabin
Pintail
Mallard
Canvasback
Canada Goose
Whitefish
Muskrat
Coyote
Lynx
Weasel
Black Bear
Owl
Moose
Moose
Wolf
Beaver
Mallard
Rabbit
Rabbit
Lynx
Moose
Lynx
Coyote
Squirrel
Shell Lease 13 Muskeg River Traditional Resource Use
Hydrography
Hydrography
ALSANDS Site
Traditional Trails
Traditional Birds
Traditional Human
Traditional Mammals
Traditional Fish
Trapping Areas
Shell Lease 13

Appendix B

Shell Canada Limited

Natural Resources Canada
Voluntary Challenge and Registry Program
Action Plan Update

August 1997

Shell Canada Limited

C. W. Wilson
President and
Chief Executive Officer

400 Fourth Avenue Southw
Calgary, Alberta T2P 0J4
(403) 691-4400

August 29, 1997

Ms. Sue Kirby
Director General
Energy Policy Branch
580 Booth St., 19C4
Ottawa, Ontario
K1A 0E4

Dear Ms. Kirby

Subject: Voluntary Challenge and Registry Program 1997 Action Plan Update

Please find attached Shell Canada's second update to our climate change action plan first submitted in September, 1995 as part of the Voluntary Challenge and Registry Program. We remain committed to the program and reaffirm our objective to achieve stabilization of Shell Canada's CO_2 and total greenhouse gas emissions at 1990 levels by the year 2000 for our 1994 level of business activity.

Since our original submission we have been able to develop more definitive plans and have improved our energy tracking information systems. In 1997 an outside consulting firm was retained to develop reporting systems and verify historical data in the upstream. One significant impact of this activity was the lowering of our 1990 base by 400,000 tonnes per year CO_2 emissions. Also in the upstream, we now estimate an increase of 250,000 tonnes per year CO_2 emissions for additional energy demand for extracting oil and gas from depleting fields. As a result, our current forecast, which is based on an aggressive energy efficiency program, will put our year 2000 total greenhouse gas emissions at 102 percent of the revised 1990 base levels. Our challenge will be to find and implement additional projects to meet our stated objective.

The attached report includes our estimated emissions for the years 1990, 1995, 1996 and a forecast for the year 2000. Some of the more significant achievements in 1996 are also included. If you have any comments or questions on this report, please feel free to contact me or Dr. Linton Kulak, Director of Corporate Health, Safety and Environment, at (403) 691-2091.

Yours very truly,

CWWilson

C. W. Wilson

EXECUTIVE SUMMARY

Shell Canada reaffirms its support of this voluntary initiative as an effective means for reducing emissions and improving the energy efficiency and competitiveness of our industry. It is consistent with our sustainable development philosophy which promotes the integration of economic and environmental decision making.

Since 1990, as a result of energy conservation activities, our operating facilities have achieved a 670,000 tonnes per year reduction in CO_2 emissions. This represents about 8 percent of the 1990 CO_2 emissions. Between now and the year 2000 we are targeting an additional 340,000 tonnes per year reduction from planned energy conservation projects and activities.

Change in the overall level of business activity is also an important factor affecting our emissions. In the period 1990 to 1996 new investments less divestments added 270,000 tonnes per year of CO_2 to our emissions. Included in this total are the new Caroline Complex brought on stream in 1993 and debottlenecking of our Scotford refinery. These items were partially offset by the shutdown of our Balzac refinery, conversion of our Shellburn refinery to a terminal and a number of smaller divestments. At the end of 1996 the Chemical business was sold, resulting in a downward adjustment to our base of 430,000 tonnes per year of CO_2 emissions.

We have now forcast more definitively the additional energy required to extract oil and gas from our depleting fields. The current forcast is that the energy required will add 250,000 tonnes per year additional CO_2 emissions by the year 2000. Increased refinery throughput is expected to add a further 120,000 tonnes per year.

We remain committed to meeting our objective to stabilize greenhouse gases at 1990 levels by the year 2000 for the 1994 level of business activity. Our current forecast shows greenhouse gas emission levels by the year 2000 to be at 102 percent of the lower, revised base which accounts for the sale of the Chemical business. Our challenge will be to identify additional energy conservation projects to offset the increase in energy demand required to extract oil and gas from depleting fields. These requirements are becoming clearer as we approach the year 2000 and are substantially higher than estimated in previous submissions.

INTRODUCTION AND COMMITMENT

In 1995 Shell Canada accepted the challenge of the Voluntary Challenge and Registry Program and submitted its first action plan. This is the second update to the plan which records our progress to date and sets out our plans and forecast to the year 2000. In future submissions we plan to forecast on a five year horizon.

Shell Canada has a stated objective to manage greenhouse gases and a plan to achieve it. The focus of our plan is improving the energy efficiency of our operations to offset the increasing demand for energy required to extract oil and gas from depleting fields and for increased refinery processing. The action plan has the full support of senior management who review progress on a regular basis, as does the Shell Canada Board of Directors

In 1996, Shell's president and CEO, Charles W. Wilson, was a member of the Minister's Advisory Council on Industrial Energy Efficiency and currently serves on the Climate Change Voluntary Challenge and Registry task force

Greenhouse gas management is an important performance element in the environmental excellence component of the company's business strategy. Environmental excellence is also part of each employees performance contract and is a factor in their reward and recognition.

COMPANY PROFILE

Shell Canada Limited is a major integrated petroleum and petrochemical company. At the end of 1996 the chemical business was sold and all future reports will exclude their emissions. The upstream business sector is involved in the exploration and development of oil and natural gas reserves and the production and marketing of oil, natural gas, natural gas liquids and sulphur. The downstream business sector produces and markets refined products such as automotive and aviation gasolines, diesel fuels, jet fuels, asphalts, heavy fuel oils, lubricants and petrochemicals. Shell currently operates 12 major oil and gas facilities located in British Columbia, Alberta and Saskatchewan, and three refineries located in Quebec, Ontario and Alberta.

OBJECTIVE

Our objective, as stated in our original action plan, is to achieve stabilization of Shell Canada's CO_2 and total greenhouse gas emissions at 1990 levels by the year 2000 for our 1994 level of business activity.

BASIS FOR EMISSION REPORTING

The reported emissions are based on facilities that were owned and operated by Shell at any time between 1990 and 1996, and those acquisitions owned and operated by others in 1990 which have since become Shell property. A complete listing of facilities considered can be found in Appendix II.

Direct sources of CO_2 include fuel combustion, flaring, formation CO_2 released from oil and gas production, and CO_2 released in the production of hydrogen. Purchased electrical energy is also included as an indirect source.

The following were used to estimate CO_2 and greenhouse gas emissions:

- CO_2 and other GHG emissions from fuel combustion in the upstream are based on factors provided by the Canadian Association of Petroleum Producers (CAPP).
- CO_2 emissions related to oil and gas production are calculated from measured flows and concentrations.
- Downstream combustion CO_2 emissions are based on the actual fuel quality used in our refineries and fuel specific emission factors.
- Indirect CO_2 emissions from purchased electricity are based on factors provided by Natural Resources Canada.
- Environment Canada CO_2 equivalence factors were used for other greenhouse gases (N_2O = 320, CH_4 = 24.5)

OVERALL GREENHOUSE GAS EMISSIONS AND FORECAST

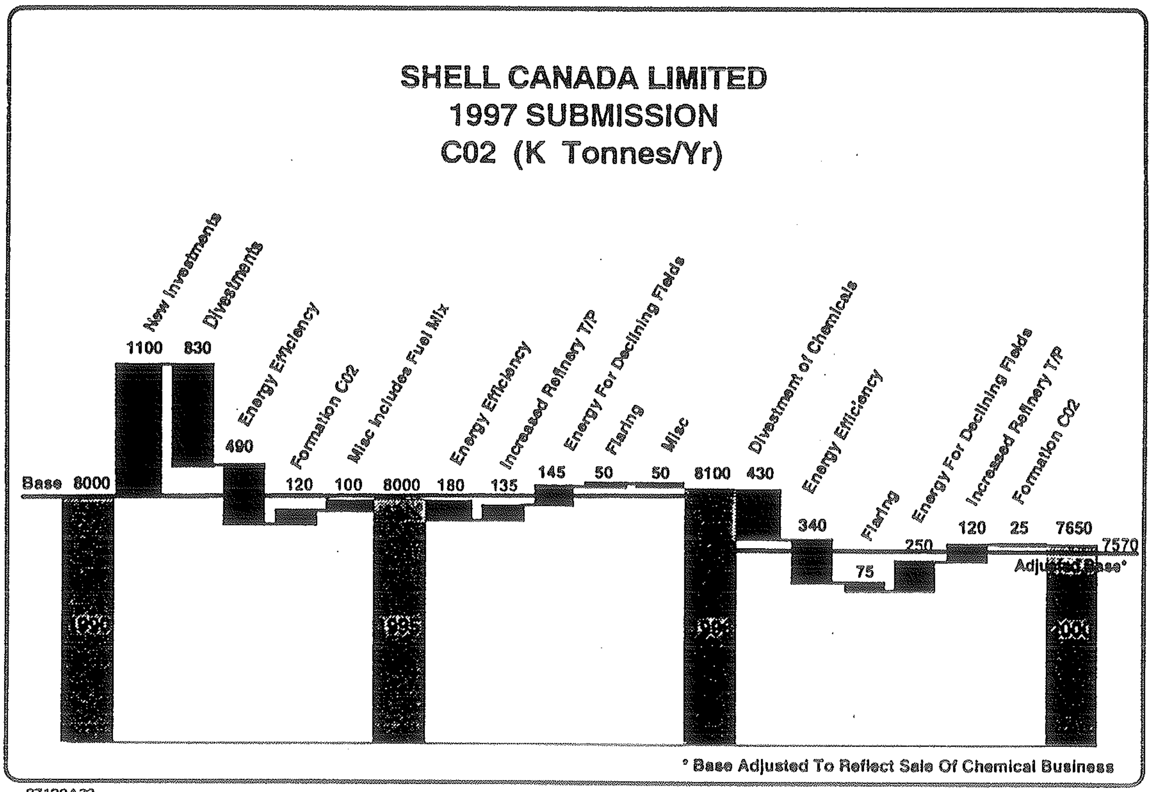
Appendix I contains our best estimates of CO_2 and total CO_2 equivalent greenhouse gas emissions for the years 1990, 1995, 1996 and 2000. In 1997 the upstream business undertook a major project to improve the system for measurement and tracking of energy consumption and CO_2 emissions at its facilities. An outside consulting firm was contracted to develop reporting systems and to verify historical data from 1990. One outcome of this review was a downward adjustment to the 1990 base year of 400,000 tonnes resulting largely from a recalculation of formation CO_2. Our 1990 base line has also been adjusted downward 430,000 tonnes in the period 1997 to 2000 to reflect the sale of the chemical business, which took place at the end of 1996. (see Fig. 1)

1990-1995 ACHIEVEMENTS

As shown in Fig. 1, 1990 to 1995 was a period of significant change to our business. We made major investments in a new Caroline gas plant and expansion of the Scotford refinery. At the same time a number of facilities were closed down, including the Shellburn and Balzac refineries, and a number of properties in the upstream were divested. The net result was an increase in CO_2 emissions of 270,000 tonnes per year.

As a result of capital investment and focus on energy management CO_2 emissions were reduced 490,000 tonnes per year, the equivalent of about half a Caroline gas plant. An increase in formation CO_2 produced as part of the production of natural gas and a change in the overall composition of fuel burned in refineries added 220,000 tonnes per year.

Fig. 1



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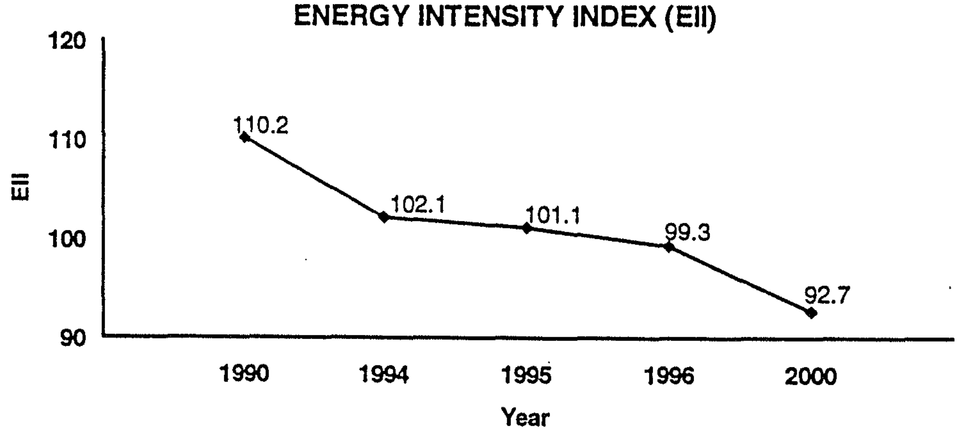
1995-1996 ACHIEVEMENTS

Our focus on improving the energy efficiency of our operating facilities to reduce CO_2 and other greenhouse gas emissions continued. As shown in Fig. 1, however, the gains were offset by increased refinery processing and a need for more energy intensive extraction of oil and gas from declining reservoirs. The overall result was a slight increase of 100,000 tonnes per year of CO_2 emissions over 1995. On a total equivalent greenhouse gases basis, emissions increased by 120,000 tonnes per year. By the end of 1996, total equivalent greenhouse gas emissions were 103 percent of the 1990 base level. (see Appendix I)

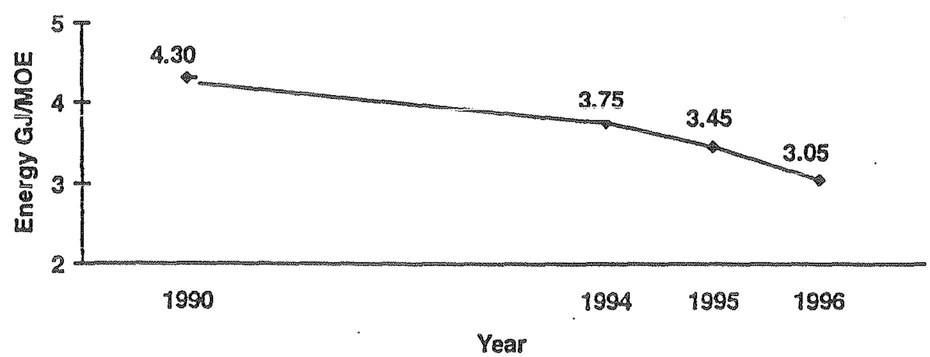
In the downstream, the energy efficiency of our refineries as shown in Fig. 2 improved by about 1.8 percent over 1995, 2.8 percent over 1994 and 9.9 percent over the base year 1990. This improvement is consistent with our commitment to CIPEC (Canadian Industry Program for Energy Conservation) to improve energy efficiency by an average of 1 percent per year over the period 1995 to 2000. Energy efficiency is measured by the Solomon Energy Intensity Index (EII), a worldwide standard used to measure the efficiency of refineries. Total capital investment in energy efficiency projects in 1996 was in the order of $10 million.

FIG 2
SHELL CANADA REFINERIES
ENERGY INTENSITY INDEX (EII)



In the upstream a number of energy improvement activities and projects were completed in 1996. As a result, the overall energy consumed per unit of production for our existing upstream properties was 3.05 GJ/MOE in 1996 vs 3.45 JG/MOE in 1995. Since 1990 the energy required per unit of production has improved nearly 30 percent. In addition to energy efficiency, this improvement was enhanced by the construction of a new energy efficient complex at Caroline and the divestment of older energy intensive properties. This trend is unlikely to continue as energy needs at depleting fields will increase as we approach the year 2000.

FIG 3
SHELL CANADA RESOURCES
ENERGY PER UNIT PRODUCTION



Some of the more significant energy efficiency projects completed or under construction in 1996 were as follows:

- At Montreal East Refinery extensive modifications were made to the Fluid Catalytic Cracking unit to improve heat integration and utilization. Modifications included a new steam generator, an additional reboiler and a new feed preheater. The project cost about $4.2 million and will save about $1,000,000 per year in fuel and electricity. CO_2 emissions are expected to be reduced by 12,000 tonnes per year.

  Also at Montreal East Refinery, controls were added to six steam turbines to allow for variable speed control. These modifications significantly reduce steam consumption and resultant generation of excess low pressure steam. These modifications are similar to variable-speed drives on electric motors but are considerably less expensive. The project cost about $100,000 and will save about $270,000 per year in fired fuel. CO_2 emissions are expected to be reduced by some 8,000 tonnes per year.

- At Sarnia Refinery a new heat exchanger was added to the Hydrocracking unit to recover heat from the reactor effluent stream. The recovered heat will be used to reduce fuel use in a downstream reboiler furnace. The project cost about $750,000 and will save about $300,000 per year in fired fuel. CO_2 emissions are expected to be reduced by 6,000 tonnes per year.

- At Scotford Refinery an on-line energy monitoring system was completed. This system provides operators and staff with current energy consumption on each process unit and compares it with a target number. A series of computer screens allow the user to trace the cause of any significant change in consumption or deviation from target. The project cost about $100,000 and is expected to save at least $100,000 per year in energy use.

- At Waterton Gas Plant a number of fuel gas turbines and pumps were converted to more efficient electrical drives. The projects cost about $ 250,000 and will reduce CO_2 emissions by 36,000 tonnes per year.

- At Caroline complex a rationalization of compression requirements allowed the shutdown of a large compressor. This combined with other minor operating modifications reduced CO_2 emissions by more than 20,000 tonnes per year.

- At Jumping Pound complex the energy requirement of the steam system was reduced by lowering the steam header pressure. In addition a number of other smaller projects including sufinol preheat modifications, electrical peak shaving and a reduction of the plant inlet pressure drop were completed. The result of these activities is expected to reduce CO_2 emissions by some 16,000 tonnes per year. These projects cost in the order of $125,000.

1997-2000 PLANS

For the period 1997 to 2000 and beyond, we will continue to focus our attention on improving the energy efficiency of our facilities.

In the downstream we are committed through CIPEC to improve the energy efficiency of our refineries by 1 percent per year until the year 2000. Between now and the year 2000 we have identified some $ 20 million worth of potential energy improvement projects in addition to those already completed. If all these projects proceed to implementation CO_2 emissions will be reduced by about 230,000 tonnes per year. We will have improved our average energy efficiency as measured by the Solomon Intensity Index (EII) by 8.3 percent over 1995 and 16 percent over the base year 1990.(see Fig 2). The projects include a number of fired heater upgrades, heat integration projects and conversions to variable speed electric drive motors.

In the upstream we have now identified a number of opportunities to improve energy efficiency. The projects include improved measurement and control systems, replacement of inefficient pumps, conversion to electricity from steam as an energy source, consolidation of equipment and reduction of pressure drop in operating systems. Implementation of these projects will have the impact of reducing CO_2 emissions by 110,000 tonnes/year. We have now defined more clearly requirements to the year 2000 for additional energy demands for extracting oil and gas from depleting fields. We now estimate an increase in CO_2 emissions of 250,000 tonnes per year compared to our previous assumption.

COMMUNITY SUPPORT

In addition to improving our own facilities, Shell is also active in promoting environmental excellence in local communities. We have established the Shell Environmental Fund which provides grants of $50 to $5000 to individuals, schools and environmental or community organizations for projects which improve or protect the environment. Since its inception in 1990, the fund has provided more than $5 million in support of about 2100 projects.

In 1996, the fund supported the planting of more than 62,000 trees identified in some 25 separate community projects. One project at the University of Western Ontario involved research work to create a solar powered car. Other projects included decommissioning unnecessary equipment, recycling, restoration, composting and education to schools and homes on energy conservation.

SUMMARY

At the end of 1996 Shell Canada's total greenhouse gas emissions were 103 percent of the 1990 base levels. To date, through an aggressive program to improve energy efficiency, we have been able to control emissions to this level despite a number of significant changes to our business which have increased the demand for energy (see Fig. 1). Without these efforts to improve energy efficiency our current greenhouse gas emissions would be in the order of 110 percent of 1990 levels.

Our objective to stabilize CO_2 and total greenhouse gas emissions at 1990 levels by the year 2000 for our 1994 level of business activity will definitely be a challenge. Our current forecast indicates we will be at 102 percent of the adjusted 1990 base year for all greenhouse gases by the year 2000. The change in our forecast from previous submissions is the result of the lowering of our 1990 greenhouse gas emissions base and better definition of the additional energy demand required to extract oil and gas from depleting fields.

Although energy efficiency is the focus of our program, we are evaluating other options to reduce greenhouse gas emissions. Minimizing flaring and controlling fugitive emissions, although minor in their impact, are being pursued. Offsets have been, and will continue to be investigated. All new projects are designed with consideration for greenhouse gas emissions. Options for such technologies as cogeneration, for example, are thoroughly investigated.

With respect to the community, we will continue to support organizations and people involved in the education and promotion of greenhouse gas reduction activities.

APPENDIX I

Shell Canada Limited
Estimated Greenhouse Gas Emissions
K Tonnes per Year

	1990	1994	1995	1996	2000*	2000**
Direct CO2 Emissions						
Combustion	5810	5365	5225	5180	4725	4700
Refinery H2 Production	380	380	400	410	420	400
Flaring	25	10	40	90	20	0
Formation CO2	570	710	695	695	715	1150
Total	6785	6465	6360	6375	5880	6250
Indirect CO2 Emissions						
Purchased Electricity	1215	1590	1640	1725	1770	1550
Total CO2 Emissions	***8000***	***8055***	***8000***	***8100***	***7650***	***7800***
N2O	90	75	75	70	70	80
CH4	560	695	705	730	700	960
Other GHG Emissions	***650***	***770***	***780***	***800***	***770***	***1040***
TOTAL GHG EMISSIONS	***8650***	***8825***	***8780***	***8900***	***8420***	***8840***

* Current Estimate for 2000 excluding sold Chemical business
** 1996 Estimate for 2000 including Chemical Business

APPENDIX II

Shell Canada Facilities included in CO2 Emission Estimates

Downstream Business

Refining and Chemical Manufacturing Complexes

• Montreal	Quebec	
• Sarnia	Ontario	
• Scotford	Alberta	
• Balzac	Alberta	Shut down in 1992
• Shellburn	British Columbia	Converted to distribution site in 1993

Lube and Grease Plants

• Montreal	Quebec	Shut down in 1993
• Toronto	Ontario	Shut down in 1992
• Brockville	Ontario	Started up in 1992
• Calgary	Alberta	

All Distribution and Marketing Sites

Upstream Business

Major Gas Complexes

• Waterton	Alberta	
• Jumping Pound	Alberta	
• Burnt Timber	Alberta	
• Caroline	Alberta	Started up in 1993

Other Oil and Gas Operations

• Limestone	Alberta
• Harmattan	Alberta
• Virginia Hills	Alberta
• House Mountain	Alberta
• Peace River	Alberta
• Hamburg	Alberta
• Bullmoose	British Columbia
• Midale	Saskatchewan

Shell Canada Limited

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P.O. Box 100, Station M
Calgary, Alberta T2P 2H5
TEL (403) 691-3111

August 7, 1998

Mr. Jay Nagendran
Regional Director
Environmental Protection
4th Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta
T5K 2J6

Subject: **Reference is made to Shell Canada's AEP Application No. 001-20809 for the Muskeg River Mine Project.**

Dear Mr. Nagendran,

Shell Canada (Shell) is pleased to provide you with the following information to clarify our commitments related to air and human health monitoring associated with our proposed Muskeg River Mine Project (MRMP). Comments provided by AEP staff have indicated that the information provided on these topics in the EIA, Application and Supplemental Information documents previously filed require clarification. We trust you will find the following information provides enough clarity and detail to consider our EIA complete.

<u>Air Monitoring</u>

1. Shell was accepted as a full participating industry member of the Wood Buffalo Environmental Association (WBEA) on August 5th, 1998. Shell has made a commitment to the Association that it will initiate baseline air quality monitoring for the Muskeg River Mine following the receipt of regulatory approvals for the project, as per the conditions of the approvals. Any air monitoring initiated by Shell will be compatible with the existing WBEA air monitoring system. In addition, Shell will provide to the WBEA an estimate of 1998 emissions associated with the Lease 13 Pilot Plant. Shell expects to participate on the various sub-groups of the WBEA including the Terrestrial Environmental Effects Monitoring group (TEEM).

2. Following regulatory approval, Shell will evaluate the existing WBEA Terrestrial Environmental Effect Monitoring (TEEM) program to determine whether the existing monitoring locations will adequately address potential nitrogen impacts associated with the MRMP. If required, Shell will work with TEEM to modify the acid input monitoring program and provide funding to the program.

3. Shell recognizes that a variety of oil sands mining air quality and air emissions issues are likely to emerge during the life of the mine and extraction facilities. In fact, we are already involved in discussions and initiatives associated with ozone modeling and the characterization of emissions from tailings ponds. Shell has a long history of actively participating in and helping to fund industry initiatives that address environmental issues pertinent to our operations. We will continue to do so.

4. Shell has committed to the following air monitoring for the Muskeg River Mine Project:

   - Establishment of an air monitoring station in the vicinity of the MRMP to collect information on NO_x, NO_2, NMHC, PM, meteorology and other parameters, as detailed in project approvals. This air monitoring station will operate in a manner that is compatible with the WBEA, and, in fact, subject to negotiations with the WBEA, may be integrated into the existing regional monitoring program.

   - Measurements to characterize and quantify point and fugitive sources of VOC and TRS emissions will be conducted during the pilot plant testing program.

   - Shell will submit an annual air emissions summary and evaluation report for 1998 in the first quarter of 1999.

   - Shell is evaluating an air emissions measurement program for the pilot plant. The experience from this effort will provide guidance on the scope and details of a program for the commercial plant.

   - Following regulatory approval, Shell will create an internal monitoring committee which will plan, design and implement a variety of monitoring programs, including air monitoring. The objectives and design of the air monitoring program will be determined in consultation with regulators, the WBEA, local communities and other interested stakeholders.

   - Shell will monitor NO_x emissions at mine pit boundaries.

   - Shell will develop a fugitive emissions monitoring program. The details of the program will be impacted by consultation with regulators, other industry players, local communities and experience gained during the operation of the pilot plant.

   - Shell will continue to play an active role in the ozone modeling group.

   - When commercial production begins, Shell will monitor tailings pond emissions in order to confirm emissions predictions.

<u>Human Health Monitoring</u>

1. Following regulatory approval, Shell will join with the other oil sands companies, government and regional communities in the Alberta Oil Sands Community Exposure and Health Effects Assessment Program (AOSCEHEAP).

2. Shell commits to work together with the Oil Sands industry and regional communities to address human health concerns and monitoring requirements associated with oil sands development.

3. In the event monitoring and assessment of emissions from tailings ponds identify human health risks, Shell will take necessary steps required to address the demonstrated health risk. Options for further mitigation could include higher solvent recovery and/or pond segregation.

If you have any additional questions regarding the information and commitments listed above, please do not hesitate to call.

Yours very truly,

Shell Canada Limited

D. A. Mead

for Rob Seeley
Manager, Regulatory Affairs

cc: Annette Trimbee, Director, Environmental Assessment
Richard Houlihan, Director, Oil Sands, EUB
Ralph Dyer, AEP
Kenneth Foster, AEP
Ken Banister, EUB
John Gulley, Golder Associates
Judy Smith, Oil Sands, Shell Canada Limited
Joanne Ellis, Shell Canada Limited
Doug Mead, Shell Canada Limited
Randy Rudolph, Conor Pacific
Shawna Mercer