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Golder Associates

WATER MANAGEMENT PLAN FOR THE MUSKEG RIVER MINE PROJECT

Submitted to:

Shell Canada Limited

December 1997 **972-2263**

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22 January 1998

972-2237

Shell Canada Limited
400 - 4 Ave. SW
P.O. Box 100, Station M
Calgary, AB T2P 2H5

Attention: Dr. Doug Mead, Senior Environmental Scientist
Safety and Environmental Resources

RE: Final Report - Water Management Plan for Muskeg River Mine Project

Dear Doug:

Attached is the final report for the water management plan for the Muskeg River Mine Project. The plan incorporates input from various sources including AGRA Earth and Environmental, NorWest Mine Services Ltd., CANMET, Bantrel Inc., Komex International Ltd. and Reid Crowther Limited.

We trust the enclosed mine water management plan will meet your requirements.

Should you have any questions about this report, please contact me at 299-5640.

Yours very truly,

GOLDER ASSOCIATES LTD.

John R. Gulley, M.Sc., P.Biol.
Oil Sands Project Director

Att.

cc Judy Smith (Shell)
Ian Mackenzie (EIA Project Manager)

EXECUTIVE SUMMARY

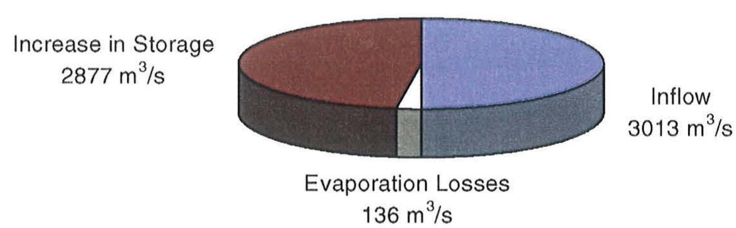
A mine water management plan has been prepared for Shell Canada Limited's (Shell) proposed Muskeg River Mine Project (the project). The plan is based on water management criteria provided by Shell and on provincial and federal project regulations and guidelines. The water balance analysis is based on available hydrologic data in addition to data from other consultants who have participated in the design of the mine plan, tailings plan and hydrogeologic components of the project.

The goal of the mine water management plan is to enable economical mine development with minimum risk to mine operations and minimum impacts on the environment. Accordingly, the plan minimizes the import of water, minimizes the volume of water in inventory, provides for sustainable reclamation drainage facilities, identifies appropriate rates of fresh water and recycle water supply, and develops an operating strategy that minimizes the cost of capital works, maintenance and operation.

The plan covers several types of facilities and activities, including: diversions, surface drainage, aquifer dewatering, water supply, water storage, process water balance and reclamation drainage. A staged system of diversion channels and drainage ditches has been designed to suit the mine and tailings plan, minimize impacts to the natural environment and delay capital works. The spacing of muskeg and overburden drainage ditches will range between 100 and 300 m, depending on the permeability of overburden material, with depths varying between 2 and 7 m. A separate polishing pond for each of four muskeg drainage systems will be used to settle solids out of the flow before it is released to receiving streams.

A large temporal variation in the raw water demand from the Athabasca River exists throughout the life of the mine. The water supply system will require a maximum annual raw water withdrawal rate from the Athabasca River of 55.1 million m^3 equivalent to 6,284 m^3/h (calendar day basis) assuming 10 year wet period conditions, during the initial years of mine operation. Raw water withdrawal rates will vary depending on process water demands, extraction water demands, the availability of recycle water and the variation of climate/hydrologic conditions. The peak annual water withdrawal will occur during the second year of operations (2003) and gradually decline to a minimum of 678 m^3/h (calendar day basis) in 2015 as the supply of recycle water increases. The maximum instantaneous rates of water withdrawal will be as high as 11,700 m^3/h for short periods of several days depending on the requirements for fire water and flushing. A minimum rate of withdrawal from the Athabasca River is necessary even when there is an overall excess of available recycle water, to supply the utilities plant with clean water. The average rate of withdrawal throughout the mining period will be 3,013 m^3/h, as shown on Figures ES-1 and ES-2. Annual outflows from the closed-circuit operations will be limited to an average of 136 m^3/h which is composed mainly of evaporation losses. The balance of the water accumulating in the closed circuit operation will be represented in sand porewater, mature fine tailings (MFT) porewater, and consolidated tailings (CT) porewater, as shown in Figure ES-2.

Figure ES-1
Mean Annual Flows from 2002 to 2022



Recycle water will comprise between 6 and 90% of the extraction water demands. Recycle water will be available from runoff within the mine area and porewater released through settleable solids removal from the thin fine tailings (TFT) and consolidation of CT. Recycle water will be combined with water supplied from the Athabasca River in the recycle pond and conveyed to the process system.

Figure ES2
Mean Annual Inflows from 2002 to 2022
(3013 m^3/h)

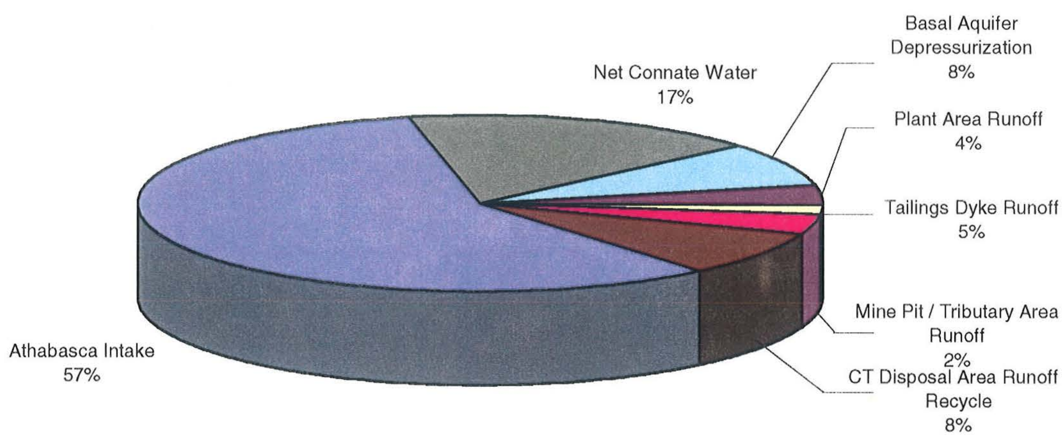
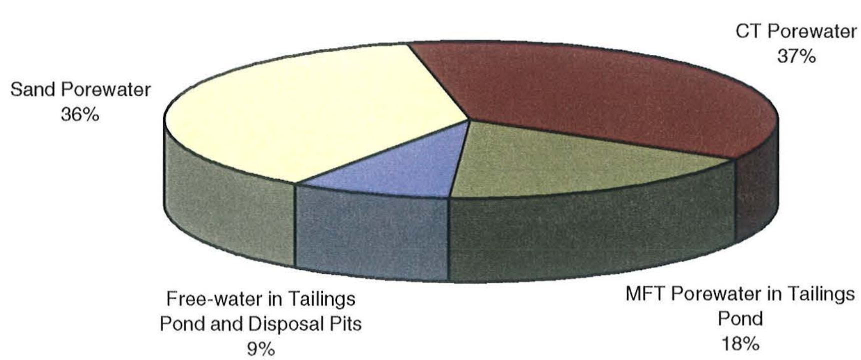


Figure ES3
Accumulated Water in Storage by 2022
(481 million m^3)



A manageable excess inventory of free-water will develop starting in 2016. The annual water balance of the project has been analyzed for each year during construction, mine operations, reclamation and far-future. Water balance schematics were developed to illustrate the inflows, outflows, changes in water inventory and internal recycle flows.

The water balance analysis indicates that excess free-water will not occur during the first 14 years of operation. Approximately 19 million m^3 of excess free-water will accumulate in the CT disposal areas during the final seven years of operation. This free-water will be pumped into the end-pit lake in 2023 after the end of mining. Approximately 66 million m^3 of MFT and 44 million m^3 of free-water will be transferred from the tailings pond to the end-pit lake starting in 2023 and finishing in 2030.

A sustainable reclamation drainage system has been designed to suit the mine plan and the tailings storage plan, minimize impacts to the natural environment and avoid unnecessary costs. The reclamation drainage system will be patterned after natural analogues to re-create a system that emulates natural drainage systems. An end-pit lake covering 343 ha will be developed at the western edge of the mine area, after mine closure. The lake will store the residual MFT after consolidation and provide for the bioremediation of porewater released from the consolidated tailings CT and TFT. Approximately 20m of non-chronically toxic water will overlay the MFT.

An independent check on the water balance was made by analyzing the total mass balance of the project. The resulting balance verifies the results of the water balance analysis.

The impact of the mine on flows of receiving streams will be minimal. The maximum mean annual withdrawal rate from the Athabasca River occurring in 2003 is less than 2% of the lowest historical monthly flow between 1964 and 1996 and about 1% of the minimum monthly mean flow. The maximum net change in the Muskeg River flow will be a decrease of less than 10% of the mean monthly flows during operations. There will be a short term increase in normal flows in the Muskeg River of 50% after mine closure and reclamation. These changes are temporary, resulting from changes in the size of the closed-circuit area, and the release of excess porewater from the tailings pond, end-pit lake, and CT storage areas. The maximum net changes will occur during the open water season (May to October). Surface water release rates from the mine disturbed area after 2030 will be similar to pre-development flow rates.

CANMET's research indicates that water quality of the recycle flows will not adversely affect extraction and tailings operations.

The proposed water management plan provides a basis to minimize risk to mining operations and avoid excessive impacts to the environment. It conforms to the requirements of both the tailings plan and mine plan. The plan provides for appropriate expenditures for maintenance, operations and capital works. It identifies the necessary raw water supply for extraction and processing while minimizing the total volume of water withdrawn from the Athabasca River and the volume of water in inventory.

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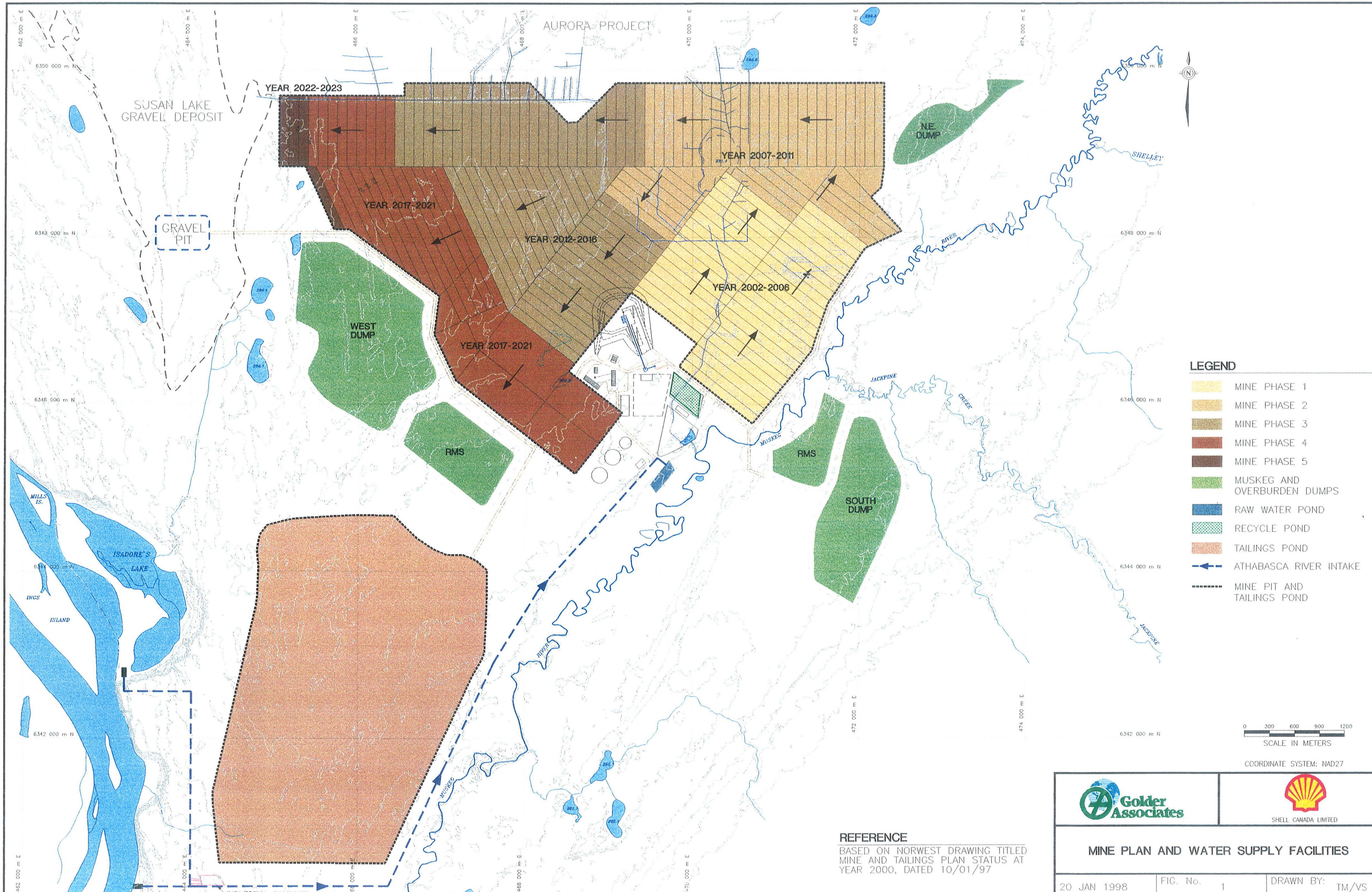
1. INTRODUCTION

This report presents a mine water management plan for Shell Canada Limited's (Shell) Muskeg River Mine Project oil sands development (the project) in Northeastern Alberta. The analysis incorporated input from various sources including AGRA Earth and Environmental (AEE) for details of the tailings plan, NorWest Mine Services (NorWest) for details of the mine plan, Bantrel Inc. (Bantrel) for details of the plant facilities, CANMET for details of the water quality, Komex International Ltd. (Komex) for details of the hydrogeology and Reid Crowther for details of the sewage water treatment plant. Figure 1 shows a composite mine plan which includes mine layout, external tailings area, overburden and reclamation material storage areas, and water supply facilities.

To develop a mine water management plan, Golder Associates Ltd. (GAL) conducted an analysis of surface water drainage conditions, sediment control systems, storage pond requirements, mine water balance, raw water intake system, site reclamation, muskeg drainage and diversion systems. GAL also compiled mine water balance inputs from the following sources:

- AEE memo to GAL dated October 28, 1997
- AEE memo to GAL dated October 1, 1997
- AEE memo to GAL dated September 24, 1997
- AEE letter to GAL dated September 29, 1997
- AEE memo to GAL dated June 25, 1997
- AEE Screening Study dated July 2, 1997
- Komex memo and schematic dated October 20, 1997
- Komex facsimile to GAL dated October 3, 1997
- Komex letter to GAL dated October 2, 1997
- Komex letter to GAL dated August 26, 1997
- Bantrel facsimile of updated mine plant water balance diagram and spreadsheet dated September 26, 1997
- Bantrel water treatment schematics from dated October September 20, 1997
- CANMET report on water chemistry dated October 7, 1997
- NorWest mine plan drawings by dated October 7, 1997



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MINE PLAN AND WATER SUPPLY FACILITIES

20 JAN 1998	FIG. No. 1	DRAWN BY: TM/VS

- Reid Crowther schematic drawings and chemical requirements for water treatment dated November 11, 1997
- Shell isopach of the basal aquifer
- Telephone conversations with representatives of NorWest, Bantrel, AEE, Komex, CANMET and Reid Crowther

Information was also compiled from an environmental impact assessment for the Aurora Mine project including the report "Climate and Surface Water Hydrology Baseline Data - Aurora Mine EIA" (AGRA Earth and Environmental). Typical water quality for surface waterbodies in and adjacent to Muskeg River Mine Project was obtained from the report "Shell Muskeg River Mine Project Winter Aquatics Field Program" (Golder Associates Ltd.). Information on licensed withdrawals in the Athabasca River basin was obtained from the Water Administration Branch, N.E.B. in correspondence dated September 19, 1997.

The purpose of this mine water management plan is to supply the necessary inputs to a mine project description needed for the Muskeg River Mine Project Environmental Impact Assessment (EIA).

2. MINE WATER MANAGEMENT OBJECTIVES AND CRITERIA

The overall goal of the mine water management plan is to support economical mine development without excessive risk to mine operations and with minimum impacts to the environment. Accordingly, a plan was developed based on the following specific objectives:

- minimize import of fresh water;
- minimize water inventory;
- allow development of practical reclamation drainage facilities;
- supply minimum required storage for fresh water and recycle water; and
- provide a practical development and operating strategy that minimizes overall costs for capital works, maintenance and operation.

The resulting mine water management plan considered a number of operating criteria and strategies for achieving economic mine development without excessive risk to mine operations and with minimum impacts to the environment. Key criteria of the mine water management plan are discussed below.

Interaction of Surface Water Between Aurora Mine and Muskeg River Mine Project

The proposed water management plan avoids interaction of surface water between the Syncrude Canada Ltd. (Syncrude) Aurora North mine and the Muskeg River Mine projects during the operating life of the mine. Existing surface flow across the lease boundary will be diverted or contained by dikes. During mining, drainage from active mining areas of the Project will be fully contained in the closed-circuit mine water management system. After mine closure, independent reclamation drainage systems will have been developed to prevent interaction of surface waters. The lease boundary between the Muskeg River Mine Project and Aurora North will become a drainage divide during operations and after closure.

It is possible that an integrated plan could be developed to combine the reclamation drainage systems of Aurora North and the Muskeg River Mine Project, if such a system proves to be practical and beneficial to the environment. However, decisions about such refinements should be made as mining progresses.

Closed-circuit Operation and Release of Mine Water

The mine water management system is based on the criterion that water in contact with oil sands will normally be contained in the mine closed-circuit. Accordingly, all mine surface drainage, plant site drainage, process water, recycle water, tailings porewater and recoverable tailings seepage will normally be conveyed to the closed-circuit mine water operation. If necessary, water in the closed-circuit operation will be released to the environment to avoid developing an excessive water inventory. Such releases will meet water quality criteria defined by government regulations and will be subject to approval by Alberta Environmental Protection (AEP).

It is assumed that basal aquifer water from depressurization wells will be used in the process water circuit. A small amount of available water quality data indicate that basal aquifer flows will likely be of acceptable quality for discharge to natural streams. If necessary to reduce water inventory, basal aquifer dewatering discharge will be released to natural streams if the quality is acceptable, either independently or in combination with overburden dewatering and muskeg drainage flows. Depending on water quality, the project will have the option of either releasing basal aquifer water to natural streams or using it in the process. However, the project will need to demonstrate the acceptability of this discharge for release and resolve release guidelines with AEP.

Minimum Disturbance to Fish Habitat

The mine plan will comply with the principle of no net loss to fish habitat. Any productive water courses disturbed during mining will be replaced with equal or better habitat. The final landscape after mine closure will replace the existing wetlands, watercourses and pond areas. Any water withdrawals from the Athabasca River will minimize disturbance of the river regime and avoid fish by appropriate sizing of intake screens.

3. MINE WATER MANAGEMENT SYSTEMS

3.1 Catchment Diversions, Muskeg Drainage and Overburden Dewatering

Water that does not come into contact with the oil sands will be released to natural receiving streams. All water will be treated for suspended sediment before release except for flows from catchment diversions. Water from muskeg drainage, overburden drainage, overburden stripping and plant site runoff during construction may contain suspended sediment and will therefore be conveyed through settling ponds before release.

Catchment diversions will be constructed to divert drainage from undisturbed areas without sediment removal because they will be designed to avoid erosion. Catchment diversions will be constructed in stages to accommodate expansion of the mine pit area and avoid unnecessary early expenditures.

Muskeg drainage is required to remove most of the free-draining water from the near-surface zone of the muskeg which is composed of highly pervious peat. This will minimize costs for water control during construction and reduce suspended sediment concentrations in drainage flows during muskeg stripping operations. Previous pilot scale trials and the experience of current oil sands operators indicate that shallow (1 to 2 m deep) muskeg drainage ditches at about 100 m spacing are effective and economical, where the underlying overburden material is composed of relatively impervious soils. Where the overburden materials are pervious sand and gravels, deep ditches at a wider spacing will be constructed. Based on previous studies, a 7 m deep ditch and a spacing of 300 m is proposed for such conditions.

The initial cost of muskeg drainage, overburden dewatering and settling ponds is based on the following assumptions:

a) Finger drainage ditches in areas where muskeg is underlain by sand or gravels

- Spacing = 300 m
- Depth = 7 m
- Side slope = 3H:1V
- Bottom width = 3 m

b) Finger drainage ditches in areas where muskeg is underlain by impervious overburden materials

- Spacing = 100 m
- Depth = 2 m
- Side slope = 1H:1V
- Bottom width = 3 m

c) Settling Ponds

- Four ponds
- Area = 3 ha each
- Water depth = 1.5 to 2.5 m
- Dyke height = 0 to 3.5 m
- Dyke length = 600 m for each pond

Design details for the finger drainage and diversion channels are shown on Figures 2, 3 and 4.

Muskeg drainage and overburden dewatering will be discharged to receiving streams as is being done at the existing Syncrude and Suncor Energy Inc. (Suncor) Oil Sands operations. Discharging this water to natural streams increases stream flows during low-flow periods, and thereby benefits fish habitat. Such discharges also compensate for loss of drainage area as a result of the closed-circuit operation in the mining areas.

Discharge of muskeg drainage and overburden dewatering flows to the Muskeg River is the most practical and environmentally sound option for handling this water. Conserving the discharge from the muskeg drainage and overburden dewatering for plant water supply might be considered in the future, however, it is expected to be impractical and uneconomical during initial operations.

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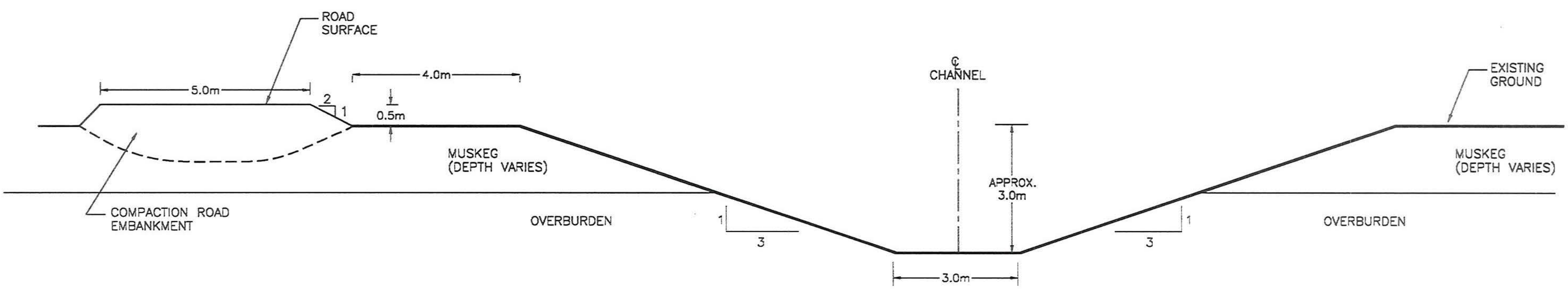

SCHEMATIC ONLY
NOT TO SCALE

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DIVERSION CHANNEL
TYPICAL CROSS-SECTION

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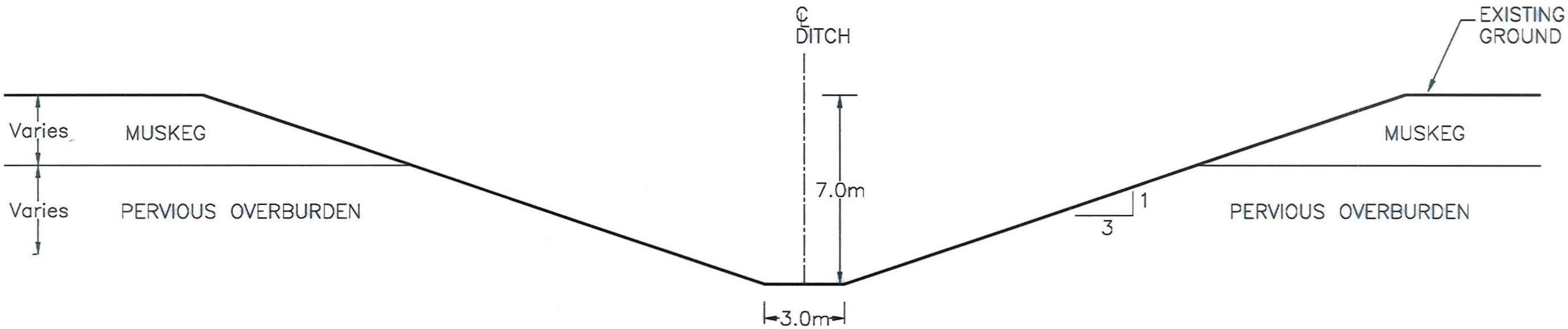

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NOT TO SCALE

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FINGER and COLLECTOR DITCHES (MUSKEG OVERLYING PERVIOUS OVERBURDEN) TYPICAL CROSS-SECTION

20 JAN 98	3	DRAWN BY: A

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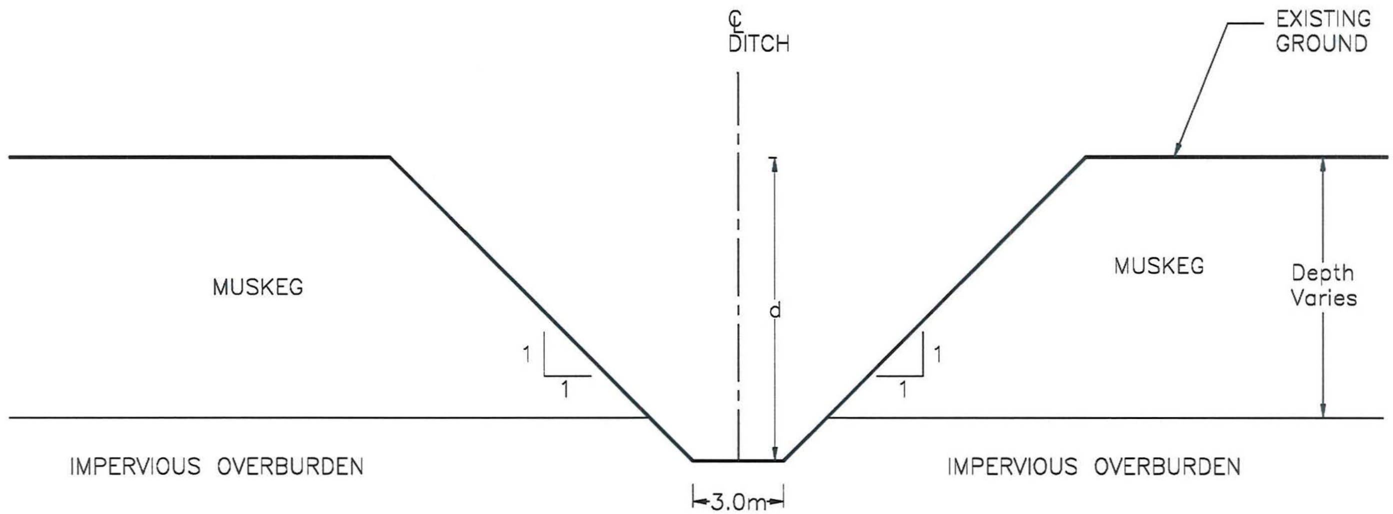

NOTE

d = UP TO 2.0m FOR FINGER DITCH

d = 2.5m FOR COLLECTOR DITCH

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NOT TO SCALE

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FINGER and COLLECTOR DITCHES
(MUSKEG OVERLYING IMPERVIOUS OVERBURDEN)
TYPICAL CROSS-SECTION

20 JAN 98	4	DRAWN BY: A

Proposed design parameters for the diversion and drainage systems area are shown on Figures 2 to 4. Slopes of muskeg drainage and overburden dewatering finger ditches are 0.2% and slopes of main collector ditches are 0.1%.

The natural drainage of the region, and of the local area around the Muskeg River Mine Project are shown on Figures 5 and 6, respectively. Plans showing a composite diversion and drainage network for the entire mine life are shown on Figures 7 and 8, respectively. The staged development of the drainage and diversion systems is shown on figures contained in Appendix I at various snapshots in time. The diversion and drainage systems will be advanced incrementally in advance of overburden removal and mining operations. The drainage network will consist of four separate systems, each discharging into separate polishing ponds. Existing drainage channels built for the Alsands Project will be used wherever possible. The requirement for diversion ditches running between the Muskeg River Mine area and the Aurora North mine will be assessed during operations. The need for these ditches will depend on the timing and progress of Aurora North mine.

The diversion system will be expanded in stages to suit the development of new pits and to minimize flow of water from undisturbed areas into the closed-circuit system. The pre-mining diversion system will divert water around the temporary oil sands stockpile and crusher site because runoff from these areas may be in contact with oil sands. Surface water will be collected from these areas and conveyed to the closed-circuit process water system.

A seepage collection ditch along the perimeter of the tailings pond dike will collect seepage and route it to one of three sumps. The water collected in the sumps will be pumped back into the tailings facility. A diversion ditch will be built at the northeast edge of the tailings pond to prevent natural flows from entering the process system.

Runoff will be collected from the overburden and muskeg dumps and the tailings pond dikes during their construction. These flows will be routed to polishing ponds to remove settleable solids before being released to receiving streams. The locations of these collector ditches are shown on Figure 8.

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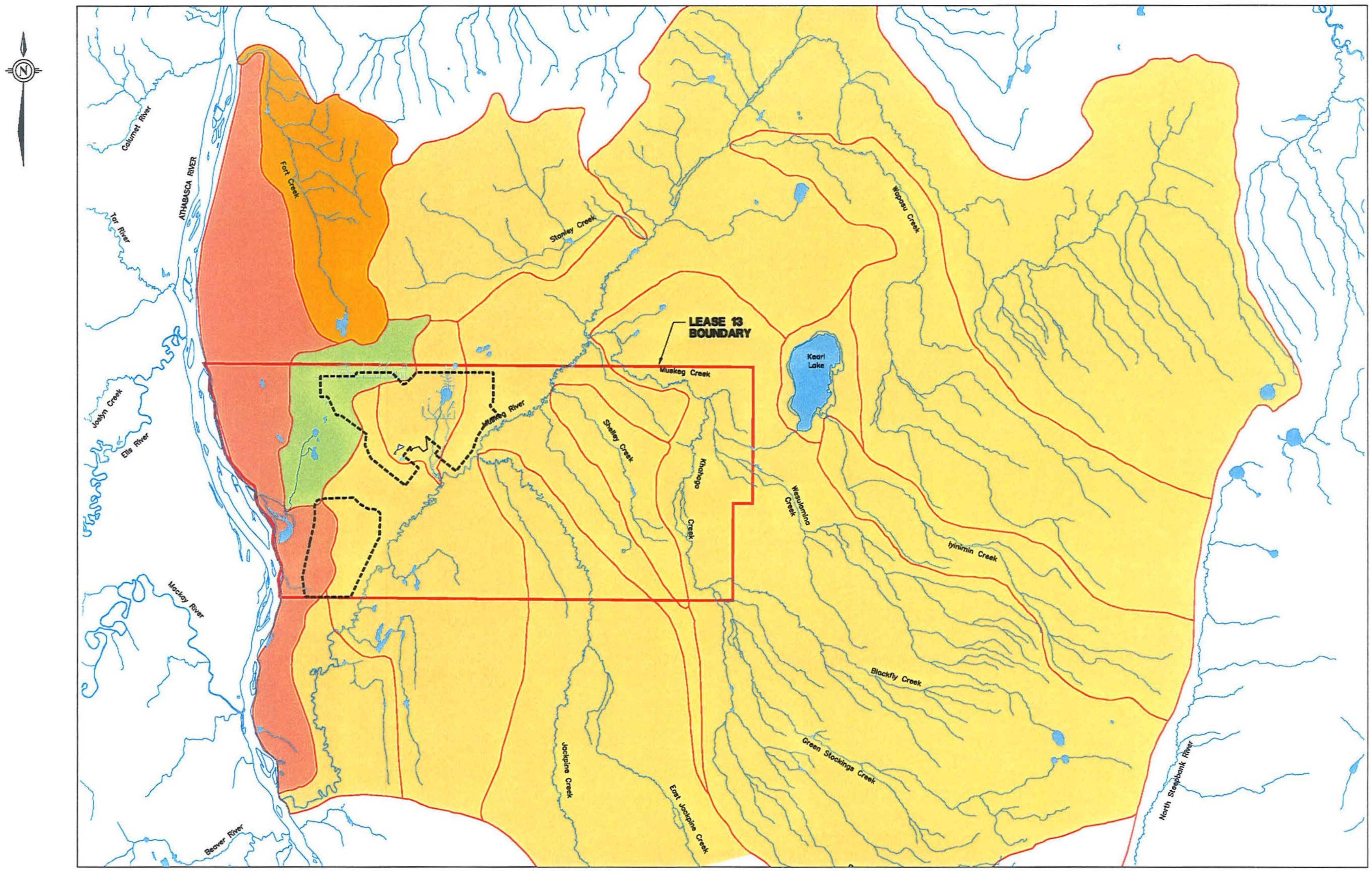

LEGEND

- WATERSHED DIVIDE
- MINE PIT AND TAILINGS POND
- MUSKEG RIVER BASIN
- MILLS CREEK BASIN
- ADJACENT TO ATHABASCA RIVER
- FORT CREEK

0 5 10km

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RIVER BASINS AT MUSKEG RIVER MINE

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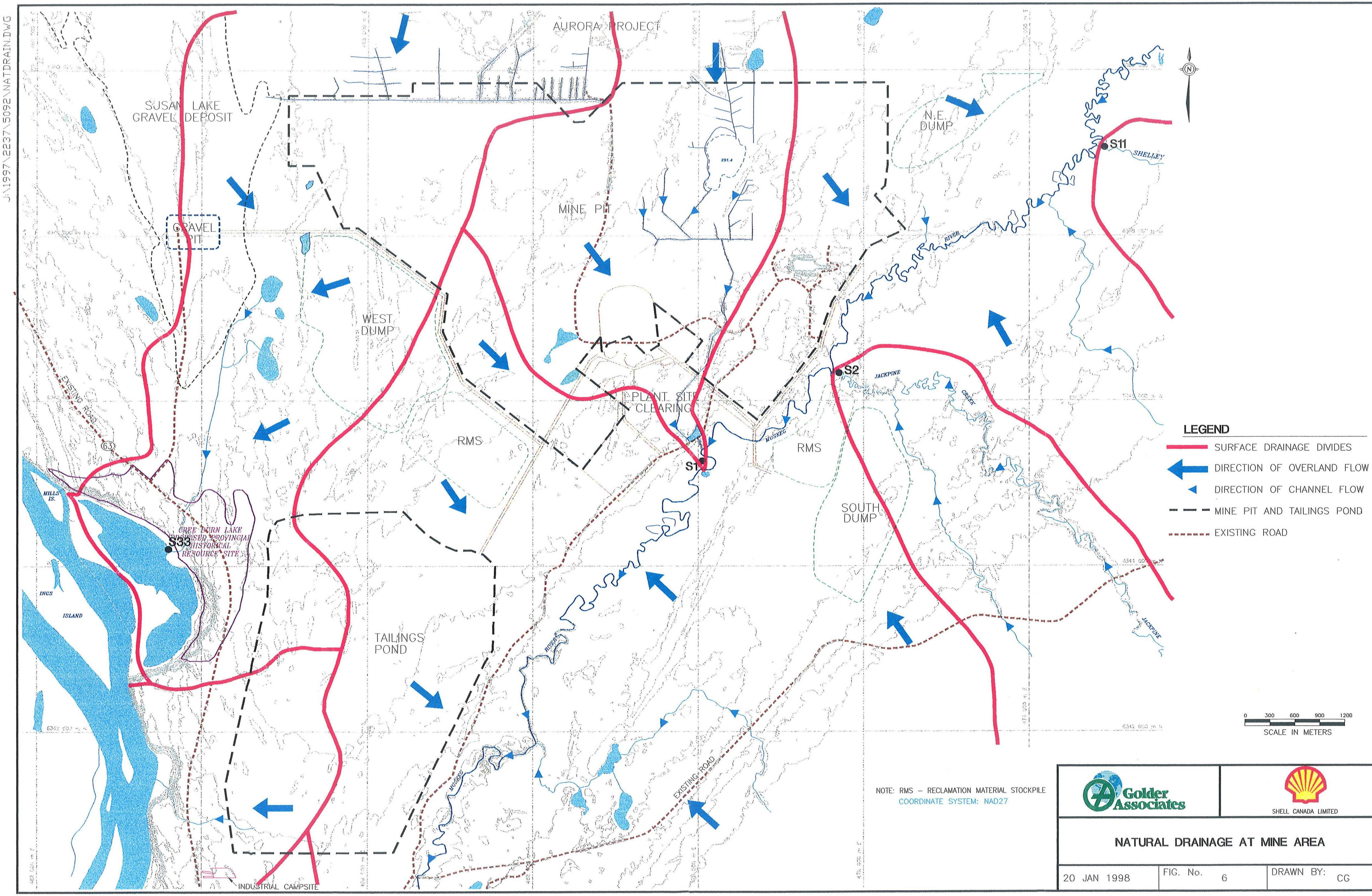

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AURORA PROJECT
SUSAN LAKE GRAVEL DEPOSIT
GRAVEL PIT
N.E. DUMP
S11
SHELLEY
MINE PIT
291.4
RIVER
WEST DUMP
S2
JACKPINE
CREEK
PLANT SITE CLEARING
RMS
S1
MUSKEG
RMS
EXISTING ROAD
63
MILLS IS.
CREE BURN LAKE PROPOSED PROVINCIAL HISTORICAL RESOURCE SITE
S33
INGS
ISLAND
SOUTH DUMP
TAILINGS POND
RIVER
JACKPINE
MUSKEG
EXISTING ROAD
INDUSTRIAL CAMPSITE
LEGEND
SURFACE DRAINAGE DIVIDES
DIRECTION OF OVERLAND FLOW
DIRECTION OF CHANNEL FLOW
MINE PIT AND TAILINGS POND
EXISTING ROAD
0 300 600 900 1200
SCALE IN METERS
NOTE: RMS – RECLAMATION MATERIAL STOCKPILE
COORDINATE SYSTEM: NAD27
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NATURAL DRAINAGE AT MINE AREA
20 JAN 1998
FIG. No. 6
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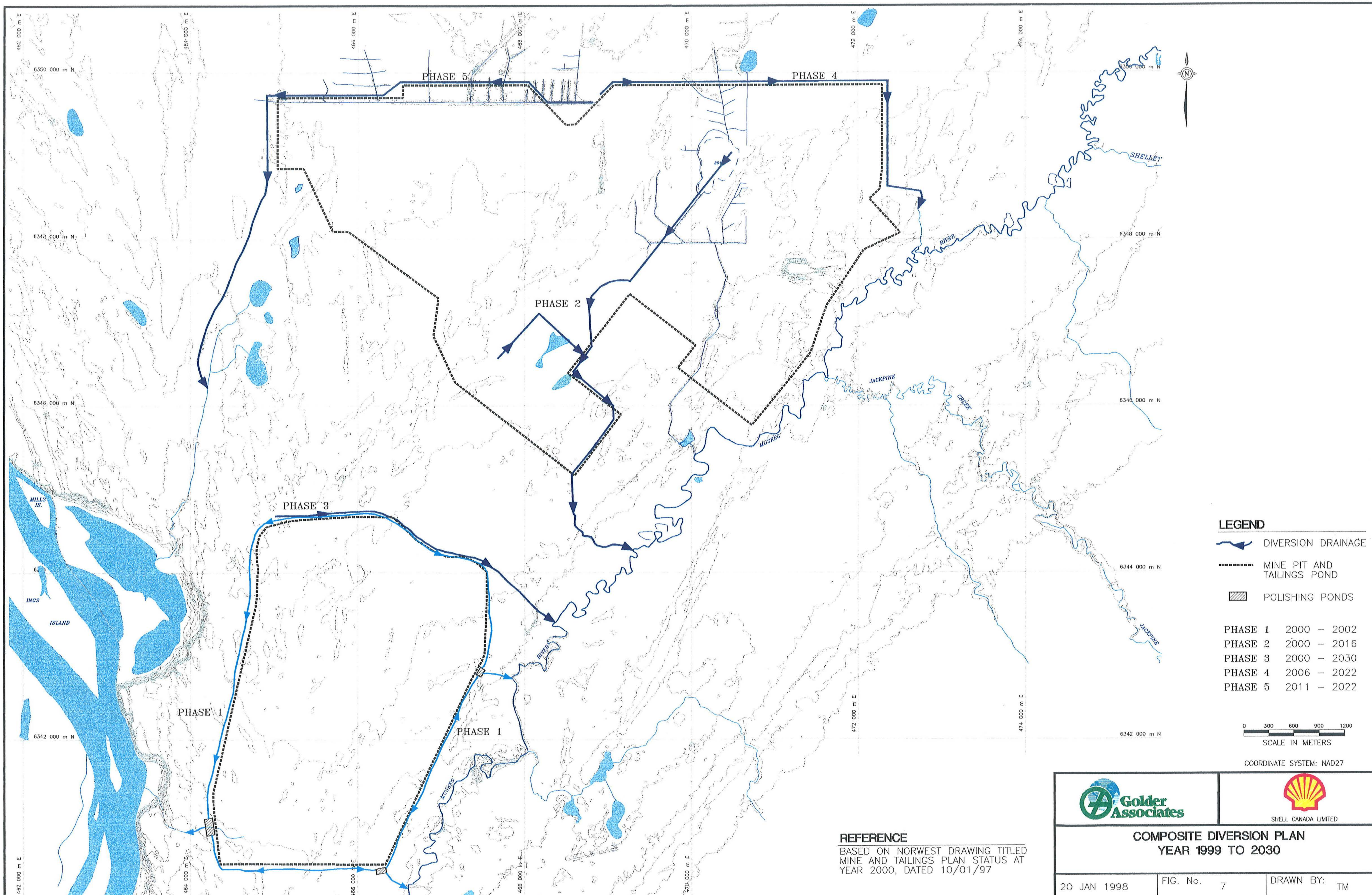

J:\1997\2237\5092\DIVDRAIN.DWG
PHASE 5
PHASE 4
PHASE 2
PHASE 3
PHASE 1
PHASE 1
MILLS IS.
ISLAND
SHELLEY
RIVER
JACKPINE
CREEK
MUSKEG
RIVER
MUSKEG
JACKPINE
462 000 m E
464 000 m E
466 000 m E
468 000 m E
470 000 m E
472 000 m E
474 000 m E
6350 000 m N
6348 000 m N
6346 000 m N
6344 000 m N
6342 000 m N
N
LEGEND
DIVERSION DRAINAGE
MINE PIT AND TAILINGS POND
POLISHING PONDS
PHASE 1 2000 – 2002
PHASE 2 2000 – 2016
PHASE 3 2000 – 2030
PHASE 4 2006 – 2022
PHASE 5 2011 – 2022
0 300 600 900 1200
SCALE IN METERS
COORDINATE SYSTEM: NAD27
REFERENCE
BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97
Golder Associates
SHELL CANADA LIMITED
COMPOSITE DIVERSION PLAN
YEAR 1999 TO 2030
20 JAN 1998
FIG. No. 7
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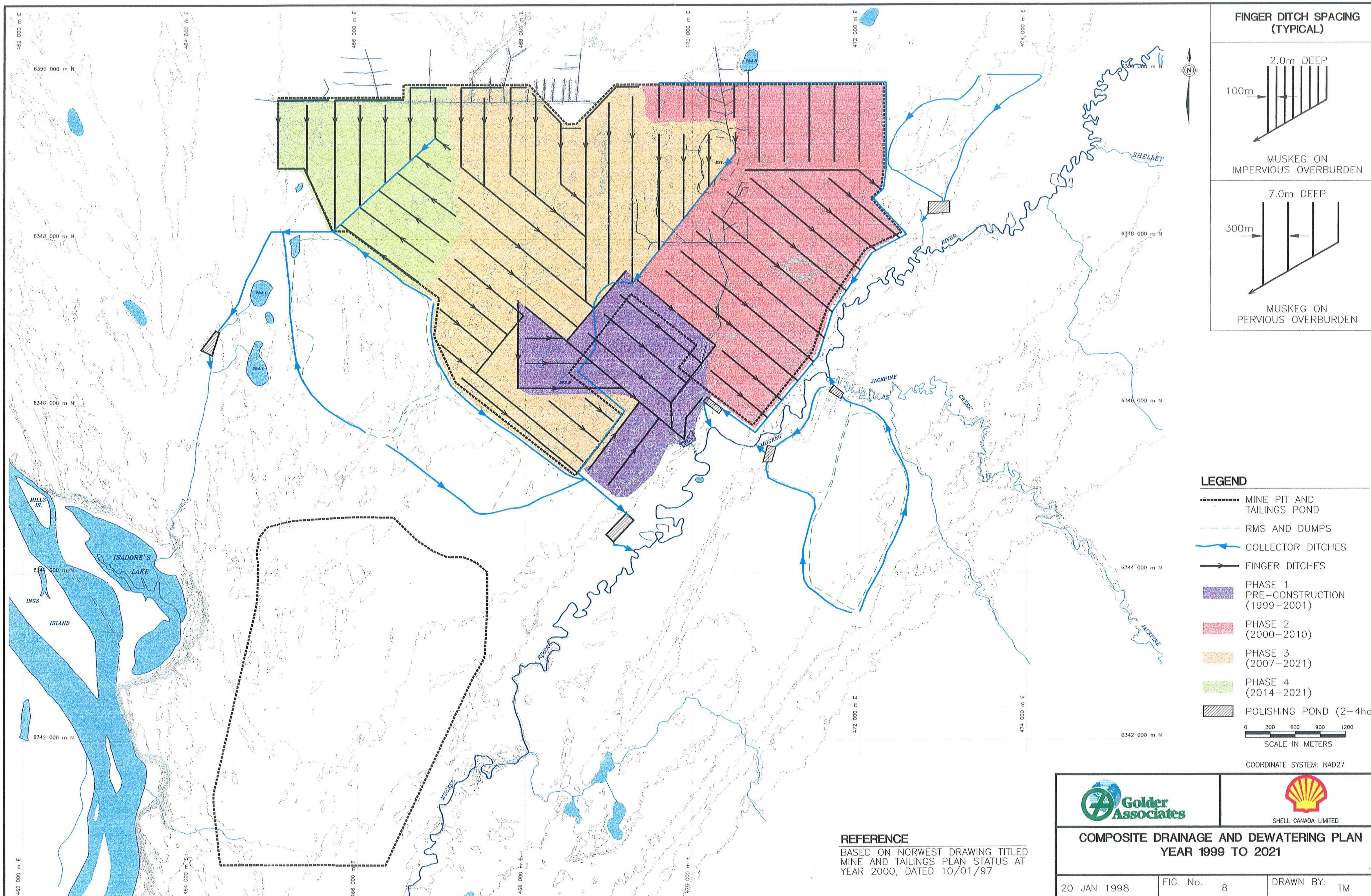
J:\1997\2237\5092\1-4PHASE.DWG
FINGER DITCH SPACING (TYPICAL)
2.0m DEEP
100m
MUSKEG ON IMPERVIOUS OVERBURDEN
7.0m DEEP
300m
MUSKEG ON PERVIOUS OVERBURDEN
SHELLEY
RIVER
JACKPINE
CREEK
MUSKEG
ISADORE'S LAKE
MILLS IS.
INGS
ISLAND
LEGEND
MINE PIT AND TAILINGS POND
RMS AND DUMPS
COLLECTOR DITCHES
FINGER DITCHES
PHASE 1 PRE-CONSTRUCTION (1999-2001)
PHASE 2 (2000-2010)
PHASE 3 (2007-2021)
PHASE 4 (2014-2021)
POLISHING POND (2-4ha)
0 300 600 900 1200
SCALE IN METERS
COORDINATE SYSTEM: NAD27
REFERENCE
BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97
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SHELL CANADA LIMITED
COMPOSITE DRAINAGE AND DEWATERING PLAN YEAR 1999 TO 2021
20 JAN 1998
FIG. No. 8
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3.2 Athabasca River Raw Water Supply

A raw water supply system is required to make up the requirements for extraction process water, tailings porewater, pond evaporation, boiler feed losses and water held in inventory. Possible sources of water include the basal aquifer, a buried channel east of the Muskeg River, muskeg drainage, overburden dewatering and the Athabasca River. However, the Athabasca River is the only reliable and available source of large quantities of water for the project.

Two intake options for water withdrawal from the Athabasca River are being considered. One is a conventional river intake system similar to the ones operated by Syncrude and Suncor. Another option consists of vertical or horizontal collector wells situated in the alluvial sand/silts near or beneath the Athabasca River and in the basal aquifer. The development of vertical or horizontal collector wells in the basal aquifer may be feasible if the basal aquifer is hydraulically connected to the alluvial sand/silts beneath the river, and if the alluvial sand/silts are sufficiently pervious. Such a system is being considered because it will eliminate the need for a holding pond to remove sediment and avoid the ice problems associated with a conventional river intake.

Maximum Annual Raw Water Supply

The maximum annual withdrawal rate from the Athabasca River would occur during the first two years of operation when river water is required to supply all process demands without any contribution from the recycle system. The maximum annual river water supply required for extraction and slurry transport water at a solids content of approximately 55% (varies depending on process conditions), less a nominal amount of water from the basal aquifer dewatering, was calculated based on the following calendar day flow data provided by Bantrel and AEE:

• extraction water and slurry makeup water (from AEE)	5,659 m^3/h
• gland and cooling water supply (from Bantrel)	618 m^3/h
• utilities plant (from Bantrel)	57 m^3/h
• "less" minimum basal aquifer dewatering (from Komex)	-50 m^3/h
TOTAL	**6,284 m^3/h**

This calculation assumes a small contribution from basal aquifer depressurization and no inflow from mine and plant site runoff. This calendar day rate represents conditions during a dry period with no inflow from surface water. The average annual raw water withdrawal rate would be reduced to 5950 m^3/h for the case of average hydrologic conditions and the most likely basal aquifer depressurization rates (50 m^3/h). The above process flow rates were estimated by Bantrel and AEE for a calendar day based on peak processing rates, discounting requirements for temporary non-process flows such as fire makeup and flushing flows. This results in a maximum mean annual intake of 55,100,000 m^3 (6284 m^3/h x 24 x 365 ≅ 55,100,000 m^3/y) which is equivalent to 1.75 m^3/s (calendar day basis). The licensed annual water withdrawal should be 55.1 million m^3/y.

Peak Instantaneous Raw Water Supply

- The maximum required peak instantaneous withdrawal rate from the Athabasca River has been estimated by Bantrel to be 11,700 m^3/h. This water demand represents a temporary withdrawal capacity of perhaps several days duration. It is based on process water demands without service factors, unusual temporary water demands including fire water, flushing water and utility water and minimal inflows from basal aquifer dewatering. This peak rate is also based on the assumption that water supply from recycle operations is not available (i.e., first two years of operation). This flow meets the requirements of the extraction facility and for pumping slurry water at a solids content of 54% (lower range of solid contents). This peak water demand is calculated as follows:

• extraction and slurry makeup water (from Bantrel)	9,121 m^3/h
• gland and cooling water (from Bantrel)	1,134 m^3/h
• utilities (from Bantrel)	130 m^3/h
• fire water (from Bantrel)	1,365 m^3/h
• less minimum basal aquifer dewatering (from Komex)	- 50 m^3/h
TOTAL	**11,700 m^3/h**

This rate of Athabasca River withdrawals would only occur during the first two years of operation when recycle water is not available. The peak demand assumes a modest contribution from basal aquifer dewatering and no inflow from the mine site and plant site surface water collection system to represent conditions during an extreme drought. Bantrel has proposed a design capacity of the Athabasca River intake system of 9,000 m^3/h ($2.5 m^3/s$) and a maximum capacity of 12,000 m^3/h ($3.3 m^3/s$).

Raw Water Intake Facility

Various types of raw water intake facilities have been considered for the Muskeg River Mine Project and for the previous Alsands project. Possible locations for the raw water intake facility as identified by these investigations are shown on Figure 9. Two sites which are not shown on Figure 9 are located 6 km and 9 km north of Ings Island. Each of the bank intake sites shown on Figure 9 are located along a permanent deepwater channel of the Athabasca River, at the outside of a bend, where sediment problems would be reduced.

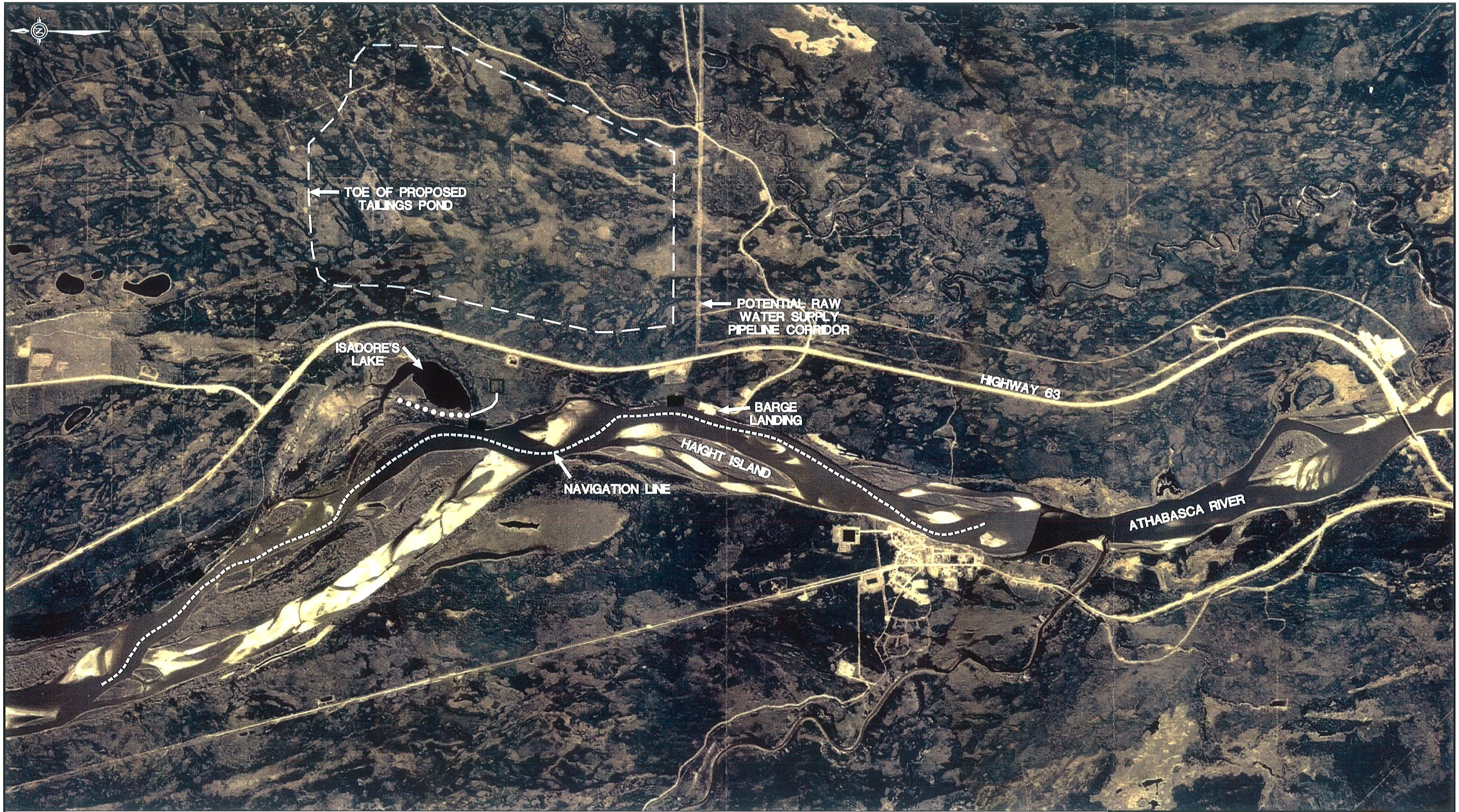
The various types of intakes considered to date are summarized below.

- Bank intake with forebay pool and screened wet-well. This type of system is being used successfully by Syncrude and Suncor. It avoids ice forces by being setback from the main river channel, but is subject to high sediment concentrations and frazil ice accumulations. Several variations of this concept include the following:

  - rock spur with pipe inlet to provide for minimum sediment entry during low flow condition. The rock spur is designed to maximize outside of bend secondary currents which will minimize entry of bedload during low flow and high flow conditions.

  - bank intake without forebay pool. This type of configuration is being used by Syncrude but it risks damage by ice forces and ice jams which occur in this area.

  - rock screen between river and forebay area to activate secondary currents for minimizing entry of bedload. This scheme risks plugging of the rock drain.



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LEGEND

- FISHERIES AND OCEANS NAVIGATION CHARTS
- WELL FIELD AND BOOSTER PUMP STATION
- BANK INTAKE (3 OPTIONS)

NOTE

POSSIBLE LOCATIONS OF A WELL FIELD RAW WATER SUPPLY SYSTEM AND RIVER BANK INTAKE, ARE SHOWN FOR PURPOSES OF ILLUSTRATION

0 0.5 1.0 1.5 2.0 2.5km

SCALE 1:50,000 (Approx.)

Golder Associates

SHELL CANADA LIMITED

POSSIBLE LOCATIONS OF ALTERNATIVE RAW WATER INTAKE FACILITIES

20 JAN 1998	FIG. No. 9	DRAWN BY: TM

- Infiltration gallery. This type of system avoids the problems of ice and sediment but is not applicable to a silty sand bed river such as the Athabasca River at the proposed intake site. To supply the design intake capacity, an infiltration gallery would need to be very long (i.e., several kilometers) and would need to be equipped with a reliable back flushing system.

- Instream river bottom intake. This type of system is used on gravel bed rivers but should not be applied to sand/silt bed rivers such as the Athabasca River because of the large bed load and the occurrence of migrating sand dunes which could plug the inlet. Suncor has replaced such an intake system with a bank intake. An instream river bottom intake would represent a risk to navigation and is therefore not given further consideration for the Muskeg River Mine Project.

- Well field composed of vertical or horizontal wells into the basal aquifer and local pervious alluvial deposits. Such a system is highly advantageous because it avoids the need for settling ponds, avoids sediment problems at the river intake and minimizes problems with ice.

The well field system will be used for raw water supply if it proves to be technically and economically feasible, because it avoids the problems of sediment and ice. Several locations for the well field are being considered. One of these is located on a gravel ridge between Isadore's Lake and the Athabasca River. If this site is selected, the facilities will need to be designed to accommodate floods and ice flows through Isadore's Lake. This will probably require burial of all water supply facilities in the flood plain. The wells would be equipped with submersible pumps and buried pipelines. This system would supply a booster pump station located above the riverbank.

A bank intake with forebay pool and screened wet-well will be built if the well field system proves to be unfeasible. This system will be set back from the river edge to avoid interference with navigation and to avoid ice flows and ice forces. It will include a small pond forebay area to minimize entry of frazil ice into the intake and to allow for some settling of sediment.

The wet well intake structure is located at the end of the forebay area and will be equipped with approved fine mesh fish screens capable of automatic backflushing to remove debris, sediment and ice from the screens. The screen mesh size and intake velocity will be designed to avoid impacts on fish.

The forebay area may be subject to sediment accumulation but this can be removed by periodic dredging. A rock spur on the river bank will be used to develop secondary currents which will reduce sediment concentrations. It will provide for inflow during low flow periods through several large diameter pipes located below the ice level and above the river bottom. During high flow, the rock spur will be submerged but will serve to deflect bedload away from the intake site. The river channel is relatively deep at the alternative locations of the bank intake, according to available navigational charts and airphotos taken during low flow conditions. The airphoto on Figure 9 was taken during low flow conditions and therefore shows the occurrence of sand bars and dunes. The figure shows that the proposed intake sites are clear of sand bars and appear to be at locations where the channel is permanently exposed to deep water. The sites are all located at the outside of a bend where secondary currents are expected to result in some reduction of sediment concentrations.

The proposed bank intake structure will be designed to meet the following criteria:

- inlet below the maximum winter ice thickness
- forebay configuration to minimize the entry of sediment and control frazil ice
- large open area of screen to prevent impacts to fish
- screen back flushing by compressed air to automatically clean screens of debris, ice and sediment.

3.3 Water Storage

Several water storage facilities will be constructed for mine process operations as discussed below.

Recycle Pond

A recycle pond, built by erecting a perimeter dike, to form an enclosure, will supply storage for emergency tailings discharges and emergency water supply in the event of an interruption of the Athabasca River and recycle water supply systems. It will provide 184,000 m^3 of storage (per Bantrel) for storm runoff from the plant and mine pit, and for 12 hours of emergency water supply.

Raw Water Pond

A raw water pond will also be built by erecting a perimeter dike around an enclosure. It will be larger than the recycle pond to provide a minimum detention time for solids to settle out of the water withdrawn from the Athabasca River. Bantrel has specified a raw water storage volume of about 720,000 m^3 to provide 48 hours of uninterrupted water supply.

Tailings Pond Water Storage

According to the conceptual design of the tailing disposal system prepared by AEE, it will be necessary to store up to 19 million m^3 of water in the tailings pond to develop a 3 m deep water cap over the thin fine tailings (TFT) and mature fine tailings (MFT). This is needed to enable settling of the fines without turbulence created by water waves and circulation, and to prevent re-suspension of fine tailings by wave turbulence and wind driven circulation in the pond. The 19 million m^3 water cap will be supplied by delaying recycle operations. The water cap will accumulate as the fine sediment in the TFT settles and as the MFT consolidates. According to AEE, a two-year period with no recycling is required to provide for initial settling of fines in the TFT and initial consolidation of the MFT. This period of no recycling will also allow the pond to accumulate the needed volume of water. The actual required duration for initial settling of solids and consolidation of MFT is uncertain and depends on the selected tailings process system.

The algorithm for MFT consolidation used to calculate porewater release rates is based on the percentage of solids in the fine tailings at the end of each year of placement shown in Table 1.

Table 1
Consolidation rate of MFT

End of Year	MFT Solids by Weight
1	17%
2	23%
3	26%
4	28%
5	30%

The initial solids content of the TFT (after sand has settled out) varies between 10 and 14% throughout the mining operation, depending on the processing method and the fines content of the ore feed.

AEE has assumed that there will be no recycling of tailings pond freewater during the initial two years of operation. Without recycle operations, freewater will accumulate to approximately 35 million m^3 by January 1, 2004, exceeding the minimum freewater cap required for settling solids in the TFT. Accordingly, the water balance analysis is based on start of recycling on January 1, 2004. To accommodate the absence of recycle water in 2002 and 2003 it will be necessary to supply additional water from the Athabasca River raw water supply system. This will result in a period of unusually high rates of raw water supply in years 2002 and 2003, prior to start of recycle operations.

In addition to the TFT, MFT and freewater storage required in the tailings pond after startup, it will be necessary to store some water in the tailings pond or other water storage pond, before mining starts. Drainage from the crusher excavation area cannot be released to receiving streams because the surface water will be in contact with the oil sands and therefore must be stored on-site and included in the mine process circuit. In addition to these flows, surface runoff inside the diked tailings pond area will accumulate in the tailings pond area. When combined, these volumes will require storage for up to 1.6 million m^3 by the end of November 2001. If the year 2002 happens to be a 10 year wet period, storage of water in the tailings pond will be 3.0 million m^3 by July 2002.

3.4 Basal Aquifer Depressurization

The layout of the depressurization wells shown in Figure 10 is a preliminary design. The schematic identifies the approximate number of wells necessary to drawdown the basal aquifer based on the isopach shown on Figure 11, and indicates that this drawdown is feasible. The final location of the wells will vary with the progress of mining.

3.5 Reclamation Landscape and Drainage Systems

The reclamation landscape will comprise in-pit consolidated tailings (CT) disposal areas, an external sand storage area, overburden disposal sites and an end-pit lake. Each of these facilities will be reclaimed to minimize adverse environmental impacts, control sediment yield and develop suitable productivity of the development area. The drainage systems will be designed to be sustainable with passive (minimum armouring) erosion control. Details of the end-of-mine landscape configuration and water management features of the mine closure facilities are discussed below.

Landscape Configuration

The proposed reclamation drainage system will be designed to provide positive drainage for all mine closure facilities. The end-of-mine landscape configuration shown on Figure 12, governs the effectiveness of the reclamation drainage system, future land use and sustainability of the landscape. Table 2 summarizes the pre-consolidated and post-consolidated elevations of the CT disposal areas, the final reclamation elevations of the in-pit CT disposal areas after covering with sand, overburden and reclamation soils, and the surrounding ground levels.

Table 2 shows that the post-consolidated surface elevations of the CT disposal areas are much lower than the original surface ground levels. Therefore, the surface elevations of the CT disposal areas will need to be raised to a level similar to the original ground level by filling the pit areas with sand or overburden material. Raising of the surface elevation above the consolidated CT levels is needed to provide an effective drainage system for the CT disposal areas.

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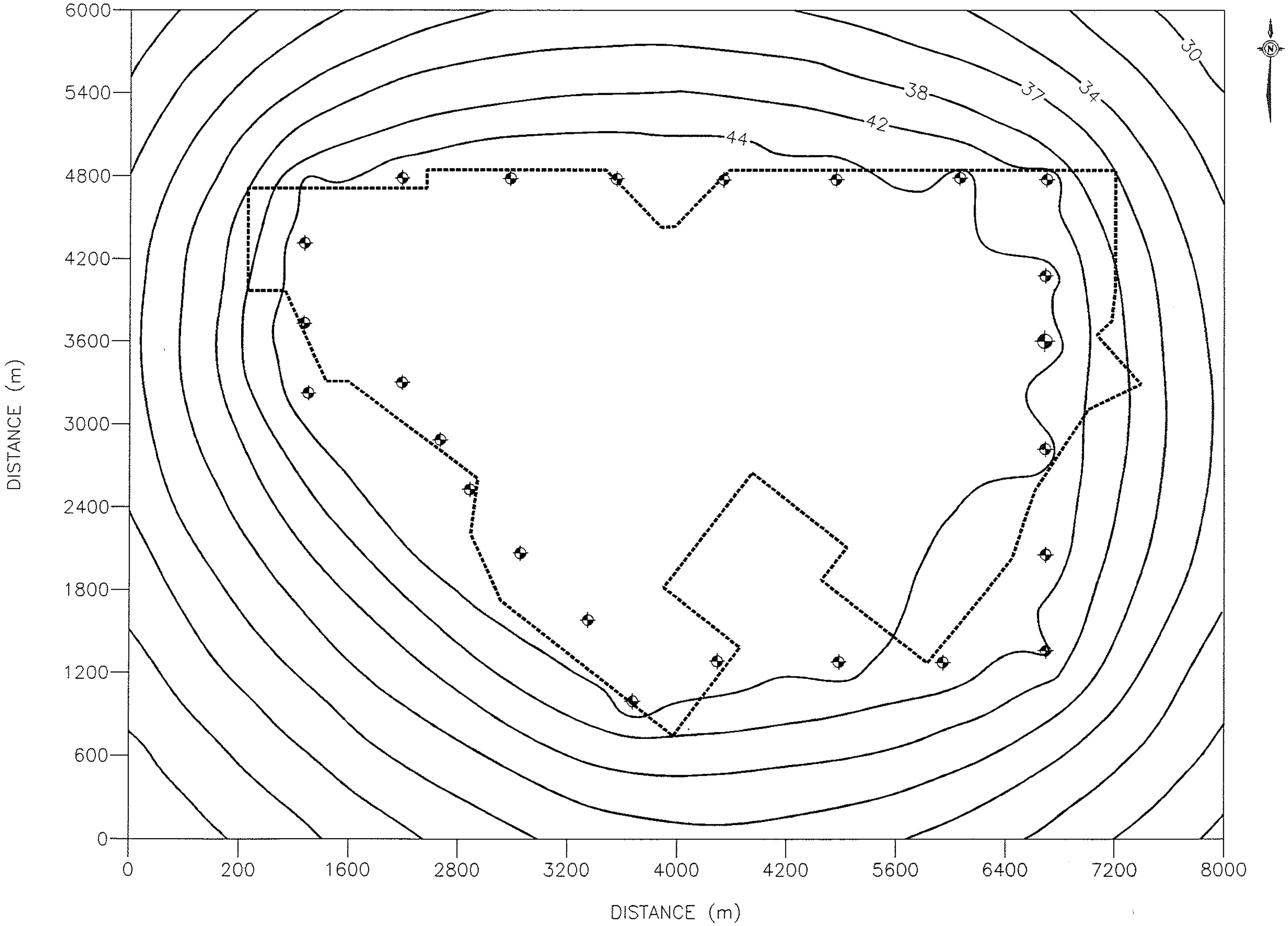


LEGEND

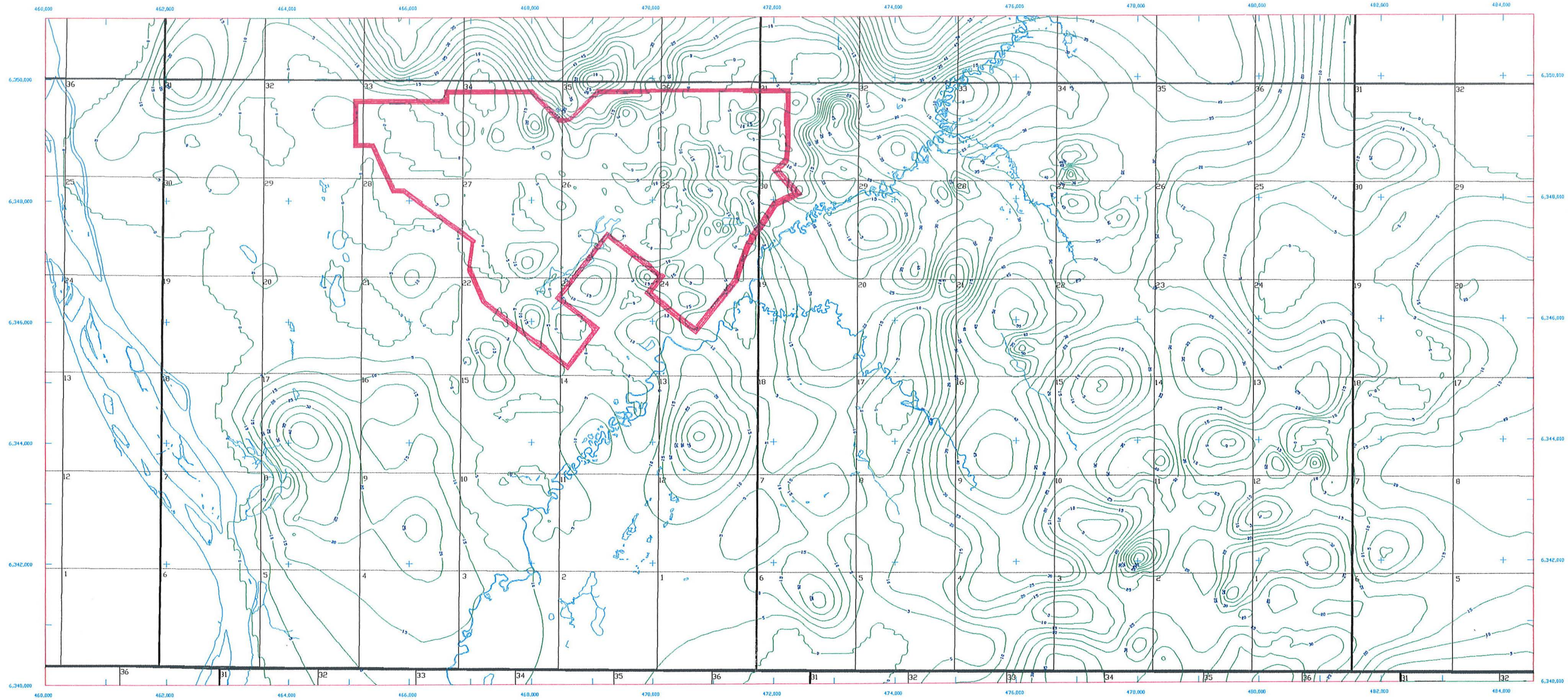
- 44 BASAL AQUIFER DRAWDOWN (m)
- MINE PIT BOUNDARY
- BASAL AQUIFER DEPRESSURIZATION WELLS

REFERENCE

DIGITIZED FROM A DRAWING PROVIDED BY KOMEX INTERNATIONAL LTD.

SCHEMATIC OF BASAL AQUIFER DEPRESSURIZATION PLAN

20 JAN 98	FIG No. 10	DRAWN BY: TM



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REFERENCE

FROM SHELL CANADA LIMITED
ORIGINAL DRAWING NAME WSISO.DWG

LEGEND

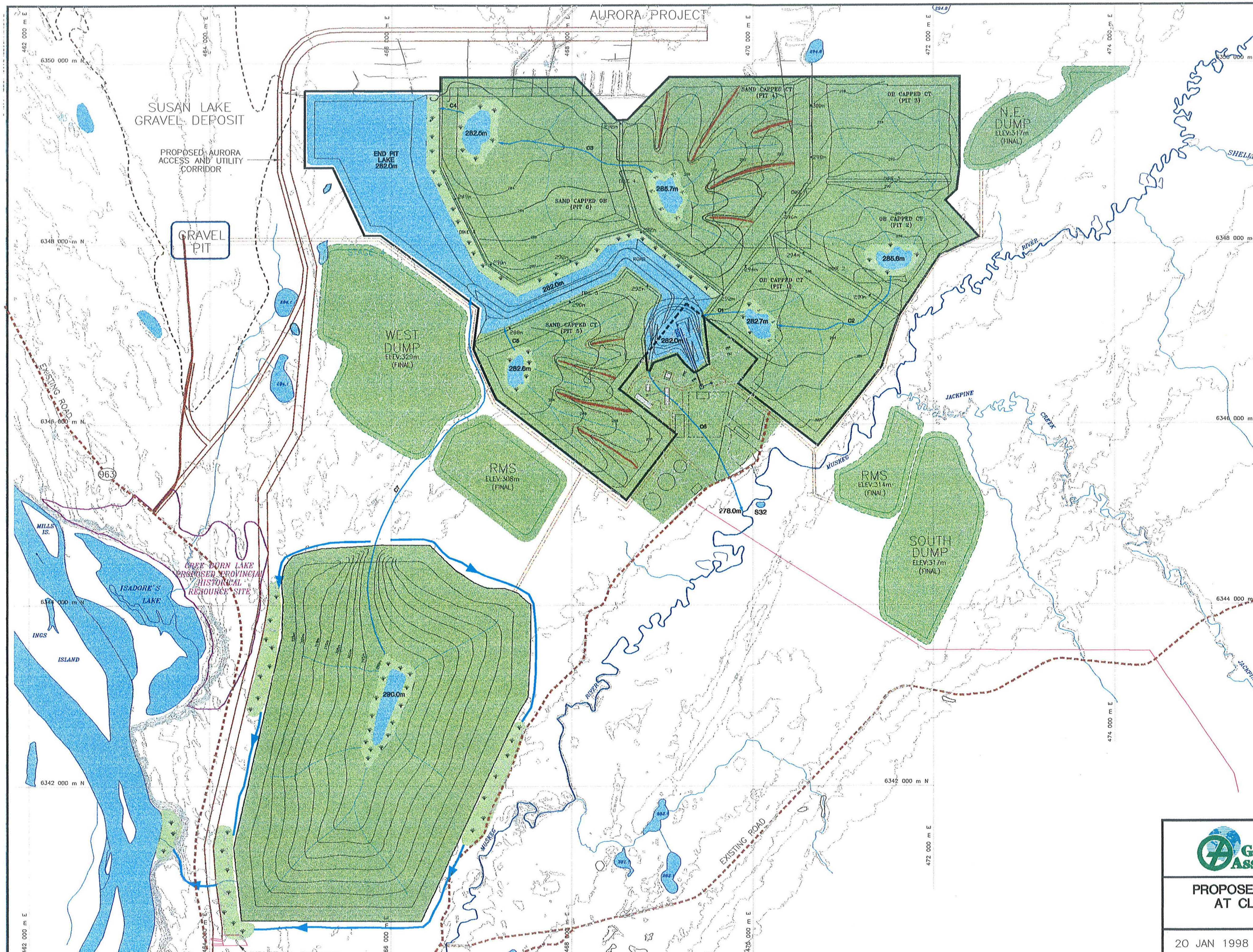
WATER SAND THICKNESS (m)
MINE BOUNDARIES

0 1000 2000 3000 4000(metres)

SCALE 1:75,000

BASAL AQUIFER ISOPACH FOR THE MUSKEG RIVER MINE PROJECT

20 JAN 98	FIG. No. 11	DRAWN BY: RFM



LEGEND

- WETLAND
- LAKE
- RECLAIMED AREA
- MAIN CHANNEL
- SECONDARY CHANNEL
- EXISTING ROAD
- SAND RIDGES
- COLLECTOR DITCHES

NOTE

ALL ELEVATIONS IN METRES

0 400 800 1200 1600 2000m
SCALE

REFERENCE

BASE PROVIDED BY NORWEST, DATED 09/09/97 TITLED MINE AND TAILINGS PLAN STATUS AT END OF YEAR 2023. 150000bbls/day SCENARIO

NOTE: RMS – RECLAMATION MATERIAL STOCKPILE

Golder Associates | SHELL CANADA LIMITED

PROPOSED RECLAMATION DRAINAGE SYSTEM AT CLOSURE AND IN THE FAR FUTURE

20 JAN 1998	FIG. No. 12	JOB No. 972-2237

Table 2
In-Pit Elevations of the Proposed Reclamation Mine Plan

Pit Number, Composition and Capping Material	Average Existing Ground Levels (m)	CT[1] Elevations (m)		Final Reclaimed Elevations after consolidation and capping (m)	Schedule of Reclamation		
		Average Pre-Consolidated Level	Average Post-Consolidated Level		End of Mining (Year)	Complete CT/ overburden placement (Year)	Final Filling and Reclamation (Year)
1. (OB-Capped CT)	290	275	272	285	2005	2011	2016
2. (OB-Capped CT)	288	283	279	288	2010	2016	2021
3. (OB-Capped CT)	292	283	279	292	2010	2016	2021
4. (Sand-Capped CT)	296	285	278	290	2013	2020	2025
5. (Sand-Capped CT)	296	283	274	287	2019	2022	2027
6. (Sand-Capped OB)	298	n/a	n/a	285	2015	2022	2023
7. End-Pit Lake	296	n/a	n/a	282	2021	--	2026

[1] Average CT elevations were provided by AEE (September 24, 1997).

The overall slope of the sand-capped and overburden-capped CT disposal areas along the drainage routes will be 0.2 to 0.3% to provide effective overland drainage and avoid fluctuating wetland levels. The CT material will consolidate up to 5 m, during the initial release of CT porewater. The period of consolidation is expected to be five to ten years.

The proposed reclamation mine plan provides a surface drainage system for collection and remediation of CT porewater, and for control of salt buildup on the surface of CT disposal areas.

Reclamation of In-Pit CT Disposal Areas

CT material represents most of the mine waste material from the mine operation and will be stored in the mine pits. The mine pits will be filled with CT to a surface elevation near original ground level, except for one area which will be filled with overburden and sand, and one area which will form the end pit lake.

Most of the CT disposal area will be very wet, similar to the existing muskeg terrain in the mine pit area. Wet soil moisture conditions and standing water are expected to characterize the lowland areas of the centre of each CT disposal site along the main drainage channel. Periphery areas below existing ground level will also be characterized by wet conditions and standing water. These areas will exhibit conditions typical of muskeg terrain, including high evapotranspiration, and potentially high flood volumes depending on antecedent moisture conditions.

The overall slope of the CT surfaces will be about 0.5%. The CT material will consolidate rapidly over five to ten years, during which time excess porewater will rise to the surface. Depending on the specific location of the reclaimed area within the mine, the time of its reclamation and the available materials, the CT surface will be covered with either hydraulically placed sand, overburden or a mixture of these materials to provide access for reclamation and to build up the tailings surface elevation to the required level, close to original ground level. A series of hydraulically placed sand ridges will be built on the sand covered CT surfaces. The sand ridges will redirect CT porewater seepage to discharge in the nearby swales. This will avoid salt accumulation on the ridges. Rainfall infiltration on the ridges will cause clean water to seep toward the swales so that salts are eventually flushed from the sand cap. The ridges will also enable early planting of upland vegetation on the CT areas. The swales adjacent to the ridges will eventually be colonized by vegetation, as the upward flux of CT porewater decreases and as salt is leached from the swale areas.

The surface of the sand cap and sand ridges will be covered with a 25 to 45 cm layer of organic soil. A schematic representation of the sand ridges is shown on Figure 13.

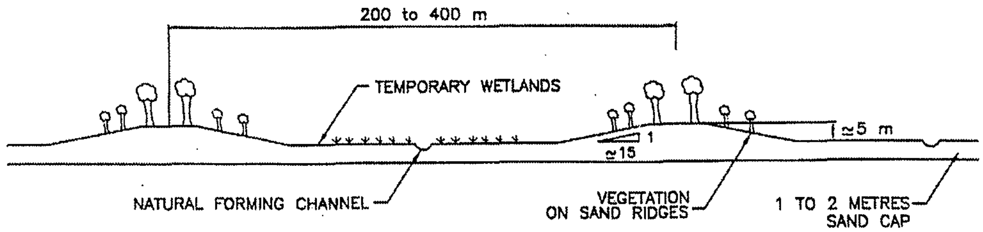


Figure 13 Reclamation Schematic

Reclamation of External Sand Storage Area (Tailings Pond)

Upon mine closure, the external sand disposal site will be prepared for reclamation by transferring the residual water cap, MFT and TFT to the bottom of the end pit lake. After removing these fluids, the tailings pond will be composed almost entirely of sand. Some of the remaining sand in the external tailings facility will be transferred to the mine pit areas by pumping, to raise the level of the CT disposal area so that it drains effectively. The surface of the external sand tailings area will be characterized by relatively steep slopes (3H:1V) on the outside perimeter and a bowl-shaped configuration in the centre. The surface will be covered by 25 to 45 cm layer of organic soil. The underlying sand materials are expected to have a grain size, gradation and permeability, similar to the relatively highly permeable sand at Suncor's existing sand structures. This sand is coarser than the sand at Syncrude's existing Mildred Lake operation, and, as a result, the surface of the proposed external sand disposal area will be characterized by rapid infiltration. Such highly permeable soils are subject to a relatively low risk of gullying after the establishment of a mature vegetative cover.

The external sand disposal site is expected to be characterized by relatively dry soil conditions capable of supporting upland vegetation. This is a result of the free-draining sand subsoils at this site.

The bowl-shaped top surface of this facility will cover approximately 6.5 km^2 and will therefore require a secure outlet channel to convey runoff from the site during extreme rainfall conditions and normal snowmelt conditions. This outlet channel will be located at the north end of the structure and will drain into the end pit lake to augment the drainage area of the lake and improve its through-flow. The end pit lake will provide a long residence time, which is needed for remediation of the runoff and seepage discharges from the sand disposal area.

The tailings pond will initially be built with relatively uniform slopes. However, in preparation for reclamation, the topography will be reconfigured slightly. This will provide for improved drainage sustainability, vegetation diversity and wildlife cover. The final configuration will consist of undulating topography at the outside face, with defined waterways. The inside bowl surface will be relatively flat with drainage courses providing a small degree of relief.

A ditch will be built at the perimeter of the tailings pond to collect seepage during mine operations. This seepage collection system will be re-graded and augmented with a series of wetlands during mine decommissioning so that it performs as a gravity flow system with a single outlet. These ponds will provide for bioremediation of the sand seepage before the flows are discharged to the Athabasca River at the southwest corner of the storage facility.

Overburden Storage Areas

Overburden disposal sites will be built at out-of-pit locations during the initial years of pit development when in-pit storage is unavailable. Side slopes are expected to be 3H:1V. During the pit development, these areas will be surrounded with drainage collection ditches. These ditches will drain to polishing ponds to settle suspended solids before discharging to natural receiving streams. The top surface will be crowned to encourage drainage to the edges of the sites. These structures will also be reclaimed with a 25 to 45 cm layer of organic soil. Reclaimed overburden areas will be subject to relatively low surface water yield in summer due to the high porosity of the reclamation soils and the well-drained conditions of the relatively steep topography. The relatively impervious subsoils and high soil moisture storage capacity of surficial soils are expected to result in conditions favourable to upland forest production. Erosion will be minimized by using passive erosion control techniques such as grass-lined waterways and drainage channels.

The overburden storage areas will be built to the same irregular topography criteria discussed above for the external sand storage area. The topography will be undulating with well-defined shallow valleys to provide defined grassed waterways and habitat for wildlife.

End Pit Lake

At the end of mine operations, two pit areas will remain unfilled because mine operations will occur at these locations just before mine closure. Without surface runoff from tributary drainage areas, inflows to the end pit lake would be limited to precipitation and basal aquifer seepage. Such flows would be insufficient to fill the pit and provide a productive aquatic environment because evaporation losses would eventually balance inflows. Consequently, the lake would become highly saline and unproductive. The lake level would also be well below the original ground level.

To avoid these conditions, a suitable tributary basin area is required to drain into the end pit lake. The catchment area should be at least five times the lake area. This will be achieved by developing an elongated end pit lake at the western and southwestern edge of the Muskeg River Mine pit area. The lake will become a receiving waterbody for drainage from all mine-disturbed areas, including the mine pit areas, the external tailings pond facility and natural tributary areas that drain toward and into mine-disturbed areas after the operational diversion ditches have been infilled and reclaimed.

A productive end pit lake is required in the far future landscape for remediation of seepage flows from CT areas. It is also needed to balance dry and wet landscapes. A large littoral zone occupying 20% of the end pit lake area will be developed along the east shore in the vicinity of the in-pit dykes to provide for biological productivity of the lake.

Filling of the end pit lake will begin in 2023 immediately after mine closure in 2022. The end pit lake will be filled with CT porewater, runoff from natural and reclaimed areas, tailings sand porewater, MFT porewater and MFT at a rate such that discharges from the lake are not acutely or chronically toxic. Two scenarios for achieving a non-toxic end pit lake discharge have been investigated:

a) Fill the end pit lake with CT porewater, surface runoff, tailings sand porewater, MFT porewater and MFT, based on a toxicity half life of 0.38 years (as used in the Aurora EIA); and

b) Same as a), but add water from the Athabasca River. This fallback approach is based on the assumption that there is no decay of toxicity.

These approaches require significant management of the lake. Under the scenario of no decay (b), inflow of Athabasca River water would be necessary for over 15 years at a declining rate, which at its peak would be less than the licensed withdrawal rate for mine operations. The end pit lake would begin discharging to the Muskeg River in 2023. Under the more supportable scenario involving a decay rate (a), Athabasca River water supply would not be necessary and the maximum period required to transfer residual volumes of tailings porewater and MFT from the external tailings pond to the end pit lake would not exceed eight years.

The end pit lake management schedule, for the case with decay, is shown in Table 3. The end pit lake would begin discharging to the Muskeg River in 2027. Initial filling of the end pit lake after mine closure in 2022, will involve transferring 19 million m^3 of CT porewater accumulation from the in-pit CT disposal areas. Free-water from the tailings pond will also be transferred to the end pit lake as shown on Table 3. This transfer will involve a gradual emptying of the tailings pond over a period of eight years. Starting in 2027, MFT will be transferred to the end pit lake over a four-year period after the MFT has consolidated to a solids content of 30%. The transfer would be made using a submerged lake bottom outlet pipe to reduce mixing and allow the MFT material to stratify permanently. Clear, non-toxic water overlying the MFT is expected to be about 19.5 m deep.

Table 3
End Pit Lake Management of Inflows and Outflows

Year End	Tailings Pond Storage		End Pit Lake													
			Inflows						Outflows			Storage		Elevation	
	MFT and TFT[1] million m³	Free-water[2] million m³	MFT from Tailings Pond million m³	Surface Runoff from CT Area million m³	Water from CT Pore Flux million m³	Water from CT Pit Storage million m³	Free-Water from Tailings Pond million m³	Precipitation onto EPL million m³	Evaporation from EPL million m³	Seepage million m³	Surface Release to Muskeg River million m³	MFT/TFT million m³	Free-water million m³	MFT/TFT m	Free-water m
End of mining - 2022	87.2	17.1												-	-
2023	75.2	23.6		6.2	8.7	19.3	7.4	1.5	2.0	0.1		0.0	41.1	-	254.9
2024	69.9	21.9		6.2	7.5		7.0	1.5	2.0	0.1		0.0	61.2	-	261.2
2025	67.2	17.5		6.2	5.3		7.0	1.5	2.0	0.1		0.0	79.2	-	266.8
2026	66.0	11.7		6.2	4.8		7.0	1.5	2.0	0.1		0.0	96.5	-	272.1
2027	52.5	4.8	13.5	6.2	3.0		7.0	1.5	2.0	0.1		13.5	112.2	245.9	280.7
2028	39.0		13.5	6.2	2.5		5.0	1.5	2.0	0.1	21.7	27.0	103.7	250.3	282.2
2029	19.5		19.5	6.2	1.8		1.3	1.5	2.0	0.1	28.2	46.5	84.2	256.6	282.2
2030			19.5	6.2	1.3		1.2	1.5	2.0	0.1	27.6	66.0	64.7	262.7	282.2
2031				6.2	1.3		1.2	1.5	2.0	0.1	8.1	66.0	64.7	262.7	282.2

Legend
- Pumping is required
- Gravity flow

Notes
1. The Volume of MFT and TFT in the tailings pond reduces continuously due to settling of solids from TFT, consolidation of MFT and pumping to the end pit lake
2. Settling of solids from TFT, consolidation of MFT, and precipitation result in a steady addition to the volume of free-water in the tailings pond.

Initial rates of outflow from the end pit lake into the Muskeg River will be approximately 0.9 m^3/s. This is 23% of the mean annual flow of 3.9 m^3/s. These outflow rates will decrease rapidly during the four years following transfer of the MFT from the tailings pond to the end pit lake. The mean annual outflow from the end pit lake will be approximately 0.22 m^3/s after equilibrium conditions have been achieved.

4. ANALYSIS OF WATER BALANCE, WATER SUPPLY AND WATER STORAGE

4.1 Water Balance Inflows, Outflows and Changes in Storage During Operation

A water balance analysis of annual inflows, outflows, recycled water and water inventory was conducted for each year of mine operation. Input data that form the basis of the mine water balance are given in Appendix II. This analysis was used to determine the flows within the mine process system, the variation of water supply requirements, the water storage inventory and any accumulation of excess water during the life of the mine. The results of this analysis are given in Tables 4 and 5.

All flows shown in this analysis are based on mean annual flow rates calculated from process flow rates by Bantrel and AEE based on a calendar day (annual average rates). Figures 14 to 24 illustrate inflows, outflows, water inventory and river water supply.

The cumulative inflows plotted on Figure 14 show high rates of inflow during the initial two years of mining when there is no recycle from the tailings pond. Cumulative inflows gradually reduce through the mine life. Natural runoff continues after mine closure in year 2022 but all other inflows reduce to zero.

Cumulative outflows, illustrated on Figure 15, are relatively constant throughout the mine life. The most significant component of the outflows is evaporation from the tailings pond. The area of the pond remains relatively constant, which results in a constant rate of outflows from the closed-circuit operations. At the end of the closed-circuit operations in 2027, discharge from the end-pit lake results in a significant increase in the cumulative outflows.

The inventory of stored water, shown on Figure 16, is composed of four main components during mining operation from year 2002 to 2022: MFT porewater, sand porewater, CT porewater, and the free-water cap in the tailings pond. The total inventory of water increases steadily during the period of closed-circuit operations from 2002 to 2027. The volume of porewater in the MFT and sand increase until full CT production begins in 2013. After 2013, increases in the water inventory occur as a result of water storage as CT porewater.

Table 4
Water Inventory During the Mine Life
(million m³)

Period Starting:	Raw Water Pond	Recycle Pond	MFT Porewater in Tailings Pond	MFT Porewater in End Pit Lake	Free-water in Tailings Pond and Disposal Pits	Sand Porewater	CT Porewater	Water in End Pit Lake	**Total Storage (million m³)**
Jan-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
May-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Nov-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
May-01	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1
Nov-01	0.4	0.1	0.0	0.0	2.2	0.0	0.0	0.0	3
Jul-02	0.4	0.1	11.1	0.0	12.3	9.2	0.0	0.0	33
Jan-03	0.4	0.1	29.8	0.0	35.0	27.5	0.0	0.0	93
Jan-04	0.4	0.1	43.7	0.0	17.5	45.3	0.0	0.0	107
Jan-05	0.4	0.1	55.9	0.0	17.3	63.3	0.0	0.0	137
Jan-06	0.4	0.1	67.2	0.0	17.1	77.4	5.5	0.0	168
Jan-07	0.4	0.1	76.5	0.0	17.5	88.6	14.4	0.0	197
Jan-08	0.4	0.1	84.7	0.0	17.8	99.8	22.7	0.0	226
Jan-09	0.4	0.1	88.9	0.0	18.2	111.1	30.3	0.0	249
Jan-10	0.4	0.1	91.3	0.0	18.5	118.5	41.3	0.0	270
Jan-11	0.4	0.1	92.5	0.0	18.9	124.6	53.8	0.0	290
Jan-12	0.4	0.1	94.4	0.0	18.8	130.9	65.1	0.0	310
Jan-13	0.4	0.1	95.6	0.0	18.6	135.7	78.3	0.0	329
Jan-14	0.4	0.1	96.8	0.0	18.5	140.6	92.6	0.0	349
Jan-15	0.4	0.1	95.3	0.0	18.5	145.6	106.6	0.0	367
Jan-16	0.4	0.1	92.5	0.0	22.2	150.4	119.0	0.0	385
Jan-17	0.4	0.1	90.0	0.0	25.4	155.0	131.1	0.0	402
Jan-18	0.4	0.1	87.6	0.0	26.6	159.7	144.0	0.0	418
Jan-19	0.4	0.1	85.4	0.0	28.6	164.3	155.8	0.0	435
Jan-20	0.4	0.1	83.3	0.0	30.2	169.0	167.6	0.0	451
Jan-21	0.4	0.1	81.2	0.0	35.6	173.7	175.7	0.0	467
Jan-22	0.4	0.1	79.4	0.0	36.4	178.3	186.8	0.0	481
Jan-23	0.0	0.0	66.0	0.0	23.6	178.3	178.0	41.1	487
Jan-24	0.0	0.0	60.7	0.0	21.9	178.3	170.5	61.2	493
Jan-25	0.0	0.0	58.0	0.0	17.5	178.3	165.1	79.2	498
Jan-26	0.0	0.0	56.8	0.0	11.7	178.3	160.4	96.6	504
Jan-27	0.0	0.0	45.2	11.6	4.8	178.3	157.3	112.2	509
Jan-28	0.0	0.0	33.5	23.2	0.1	178.3	154.9	103.7	494
Jan-29	0.0	0.0	16.8	40.0	0.0	178.3	153.1	84.2	472
Jan-30	0.0	0.0	0.0	56.8	0.0	178.3	151.8	64.7	452
Jan-31	0.0	0.0	0.0	56.8	0.0	178.3	150.6	64.7	450
Jan-32	0.0	0.0	0.0	56.8	0.0	178.3	149.7	64.7	449
Jan-33	0.0	0.0	0.0	56.8	0.0	178.3	148.9	64.7	449
Jan-34	0.0	0.0	0.0	56.8	0.0	178.3	148.4	64.7	448
Jan-35	0.0	0.0	0.0	56.8	0.0	178.3	148.0	64.7	448
Jan-36	0.0	0.0	0.0	56.8	0.0	178.3	147.7	64.7	448
Jan-37	0.0	0.0	0.0	56.8	0.0	178.3	147.5	64.7	447
Jan-38	0.0	0.0	0.0	56.8	0.0	178.3	147.2	64.7	447
Jan-39	0.0	0.0	0.0	56.8	0.0	178.3	146.9	64.7	447
Jan-40	0.0	0.0	0.0	56.8	0.0	178.3	146.7	64.7	446
Jan-41	0.0	0.0	0.0	56.8	0.0	178.3	146.4	64.7	446
Jan-42	0.0	0.0	0.0	56.8	0.0	178.3	146.1	64.7	446
Jan-43	0.0	0.0	0.0	56.8	0.0	178.3	145.8	64.7	446
Jan-44	0.0	0.0	0.0	56.8	0.0	178.3	145.8	64.7	446
Jan-45	0.0	0.0	0.0	56.8	0.0	178.3	145.8	64.7	446

(data from AGRA, September 24, 1997)

Table 5
Summary Water Balance Analysis for Average Conditions
(Flows in m^3/h)

	INFLOWS								OUTFLOWS				
Period Starting:	Athabasca Intake	Net Connate Water	Basal Aquifer Depressurization	Plant Area Runoff	Mine Pit Runoff	Tailings Dyke Runoff	CT Disposal Area Runoff / Recycle	**Total Inflows**	Boiler Feed Losses	Net Pond Evaporation	Seepage	Flows to Natural Receiving Streams	**Total Outflows**
Jan-99													
May-00				18				**18**				18	**18**
Nov-00				56				**56**				56	**56**
May-01				109		221		**329**		10		88	**98**
Nov-01	93			109		210		**411**		20		88	**107**
Jul-02	5900	488	326	109	-2	165		**6986**	4	57			**61**
Jan-03	5950	488	250	109	25	101		**6923**	4	111			**115**
Jan-04	771	488	216	109	52	102		**1738**	4	110			**113**
Jan-05	2534	488	216	109	80	104		**3530**	4	108			**112**
Jan-06	2599	488	216	109	107	105		**3623**	4	107			**111**
Jan-07	2429	488	233	109	2	103	140	**3503**	4	109	9		**122**
Jan-08	2284	488	176	109	7	100	169	**3331**	4	112	10		**125**
Jan-09	1759	488	151	109	13	97	197	**2813**	4	114	11		**129**
Jan-10	1456	488	151	109	18	95	225	**2541**	4	116	13		**132**
Jan-11	1319	488	151	109	23	92	254	**2435**	4	118	14		**136**
Jan-12	872	488	459	109	31	93	292	**2343**	4	117	16		**137**
Jan-13	890	488	359	109	38	94	331	**2309**	4	116	17		**138**
Jan-14	1029	488	313	109	46	95	370	**2449**	4	116	19		**139**
Jan-15	678	488	313	109	53	96	409	**2145**	4	115	21		**139**
Jan-16	678	488	313	109	61	97	444	**2189**	4	114	23		**140**
Jan-17	678	488	233	109	67	99	463	**2136**	4	113	25		**142**
Jan-18	678	488	177	109	71	100	402	**2023**	4	112	31		**146**
Jan-19	678	488	153	109	77	101	385	**1989**	4	111	35		**149**
Jan-20	678	488	153	109	83	102	368	**1980**	4	110	39		**152**
Jan-21	678	488	153	109	89	103	372	**1991**	4	109	41		**154**
Jan-22	678	488	90	109	91	105	269	**1830**	4	107	48		**159**
Jan-23					111	107	630	**848**		167	35		**202**
Jan-24					111	103	630	**843**		171	35		**206**
Jan-25					111	99	630	**839**		174	35		**209**
Jan-26					111	103	630	**843**		171	35		**206**
Jan-27					111	112	630	**852**		163	35		**198**
Jan-28					111	121	630	**861**		156	35	2470	**2661**
Jan-29					111	138	630	**878**		65	35	3214	**3314**
Jan-30					111	138	630	**878**		65	35	3143	**3244**
Jan-31					111	138	630	**878**		65	35	921	**1021**
Jan-32					111	138	630	**878**		65	35	874	**974**
Jan-33					111	138	630	**878**		65	35	874	**974**
Jan-34					111	138	630	**878**		65	35	828	**929**
Jan-35					111	138	630	**878**		65	35	828	**929**
Jan-36					111	138	630	**878**		65	35	809	**909**
Jan-37					111	138	630	**878**		65	35	809	**909**
Jan-38					111	138	630	**878**		65	35	809	**909**
Jan-39					111	138	630	**878**		65	35	809	**909**
Jan-40					111	138	630	**878**		65	35	809	**909**
Jan-41					111	138	630	**878**		65	35	809	**909**
Jan-42					111	138	630	**878**		65	35	809	**909**
Jan-43					111	138	630	**878**		65	35	809	**909**
Jan-44					111	138	630	**878**		65	35	778	**878**
Jan-45					111	138	630	**878**		65	35	778	**878**

	CHANGES IN STORAGE								RECYCLE FLOWS				
Period Starting:	Raw Water Pond	Recycle Pond	MFT Porewater in Tailings Pond	Free-water in Tailings Pond and Disposal Pits	Sand Porewater	CT Porewater	Water in End Pit Lake	**Total Storage**	Net Runoff	CT Porewater Recycle	Basal Aquifer Depressurization	MFT Porewater Recycle	**Total Recycle**
Jan-99													
May-00													
Nov-00													
May-01				232				**232**					
Nov-01	68	24		211				**304**					
Jul-02		0	2533	2300	2092			**6925**	105		326		**431**
Jan-03		0	2134	2581	2092			**6808**	132		250		**382**
Jan-04		0	1582	-1992	2034			**1625**	159		216	5005	**5380**
Jan-05			1396	-23	2044			**3418**	186		216	3246	**3649**
Jan-06		0	1288	-23	1615	632		**3512**	214	574	216	2828	**3832**
Jan-07		0	1061	41	1270	1010		**3381**	108	1125	233	2508	**3975**
Jan-08			930	41	1285	950		**3206**	114	1232	176	2669	**4190**
Jan-09		0	487	41	1289	867		**2684**	119	1309	151	3053	**4632**
Jan-10		0	274	41	838	1255		**2408**	125	1809	151	2537	**4621**
Jan-11		0	131	41	698	1428		**2299**	130	2107	151	2481	**4869**
Jan-12			217	-17	722	1285		**2206**	138	2396	459	2552	**5545**
Jan-13		0	138	-17	543	1507		**2171**	145	2546	359	2343	**5393**
Jan-14	0		135	-17	561	1631		**2310**	152	2597	313	2423	**5485**
Jan-15			-173	4	575	1601		**2006**	160	3081	313	2457	**6011**
Jan-16			-315	419	538	1407		**2049**	167	2978	313	2101	**5560**
Jan-17			-289	368	532	1383		**1994**	173	2528	233	2539	**5473**
Jan-18			-266	142	532	1469		**1877**	178	2591	177	2527	**5473**
Jan-19			-256	220	532	1344		**1840**	184	2697	153	2440	**5473**
Jan-20			-243	189	532	1350		**1827**	190	2798	153	2332	**5473**
Jan-21			-241	618	532	927		**1836**	196	2690	153	2457	**5496**
Jan-22			-198	83	526	1261		**1671**	198	2776	90	2354	**5418**
Jan-23	-46	-16	-1525	-1452		-1002	4686	**646**					
Jan-24			-608	-195		-859	2300	**638**					
Jan-25			-307	-504		-607	2048	**630**					
Jan-26			-142	-661		-542	1983	**638**					
Jan-27			-1326	-786		-347	1787	**-671**					
Jan-28			-1326	-542		-284	-973	**-3125**					
Jan-29			-1913	-9		-204	-2223	**-4349**					
Jan-30			-1913			-143	-2223	**-4278**					
Jan-31						-143		**-143**					
Jan-32						-96		**-96**					
Jan-33						-96	0	**-96**					
Jan-34						-50		**-50**					
Jan-35						-50		**-50**					
Jan-36						-31	0	**-31**					
Jan-37						-31		**-31**					
Jan-38						-31	0	**-31**					
Jan-39						-31		**-31**					
Jan-40						-31	0	**-31**					
Jan-41						-31		**-31**					
Jan-42						-31	0	**-31**					
Jan-43						-31		**-31**					
Jan-44													
Jan-45							0	**0**					

(data from AGRA, September 24, 1997)

Figure 14
Cumulative Inflows to Muskeg River Mine Project

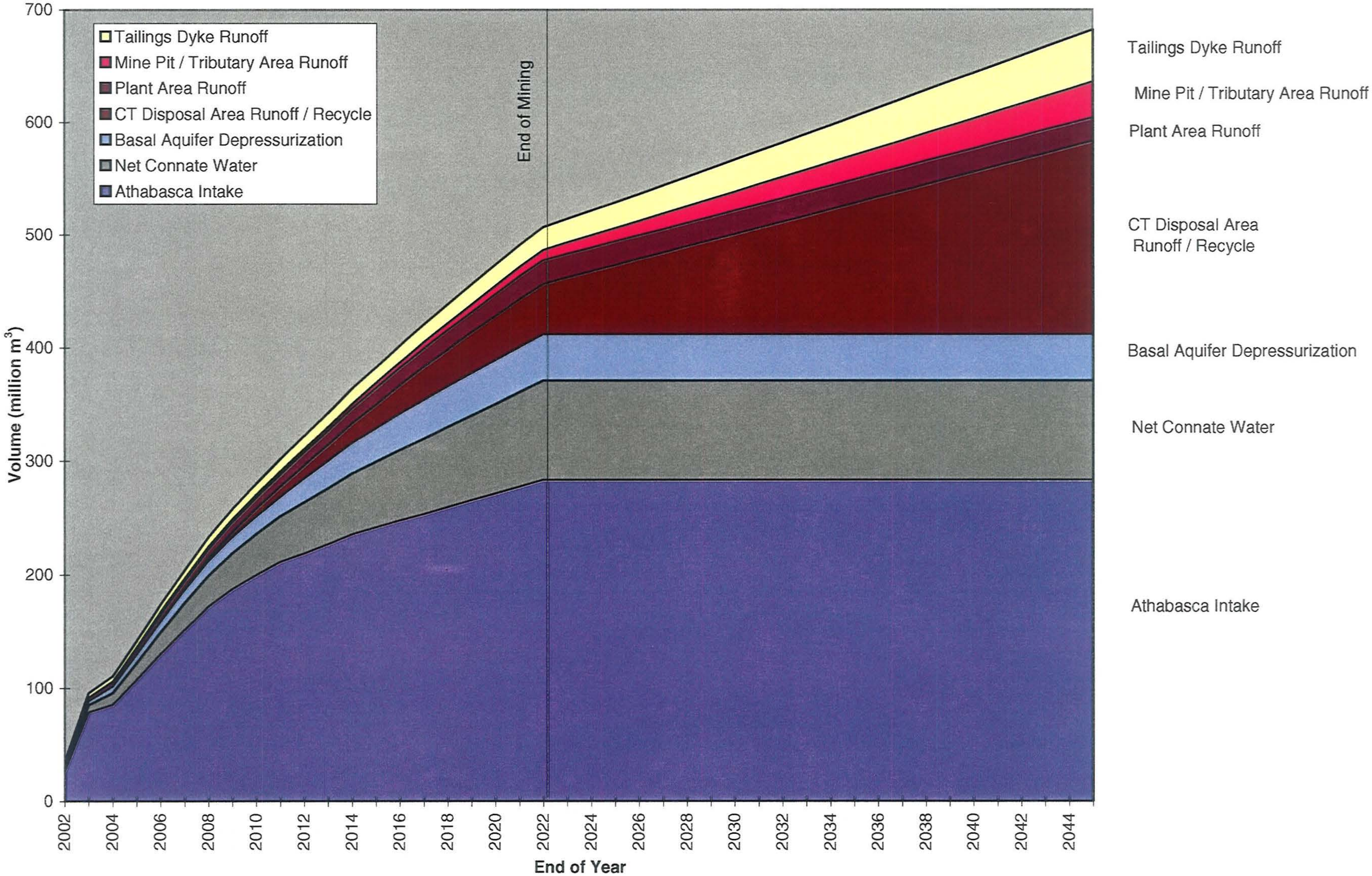


Figure 15
Cumulative Outflows from Muskeg River Mine Project

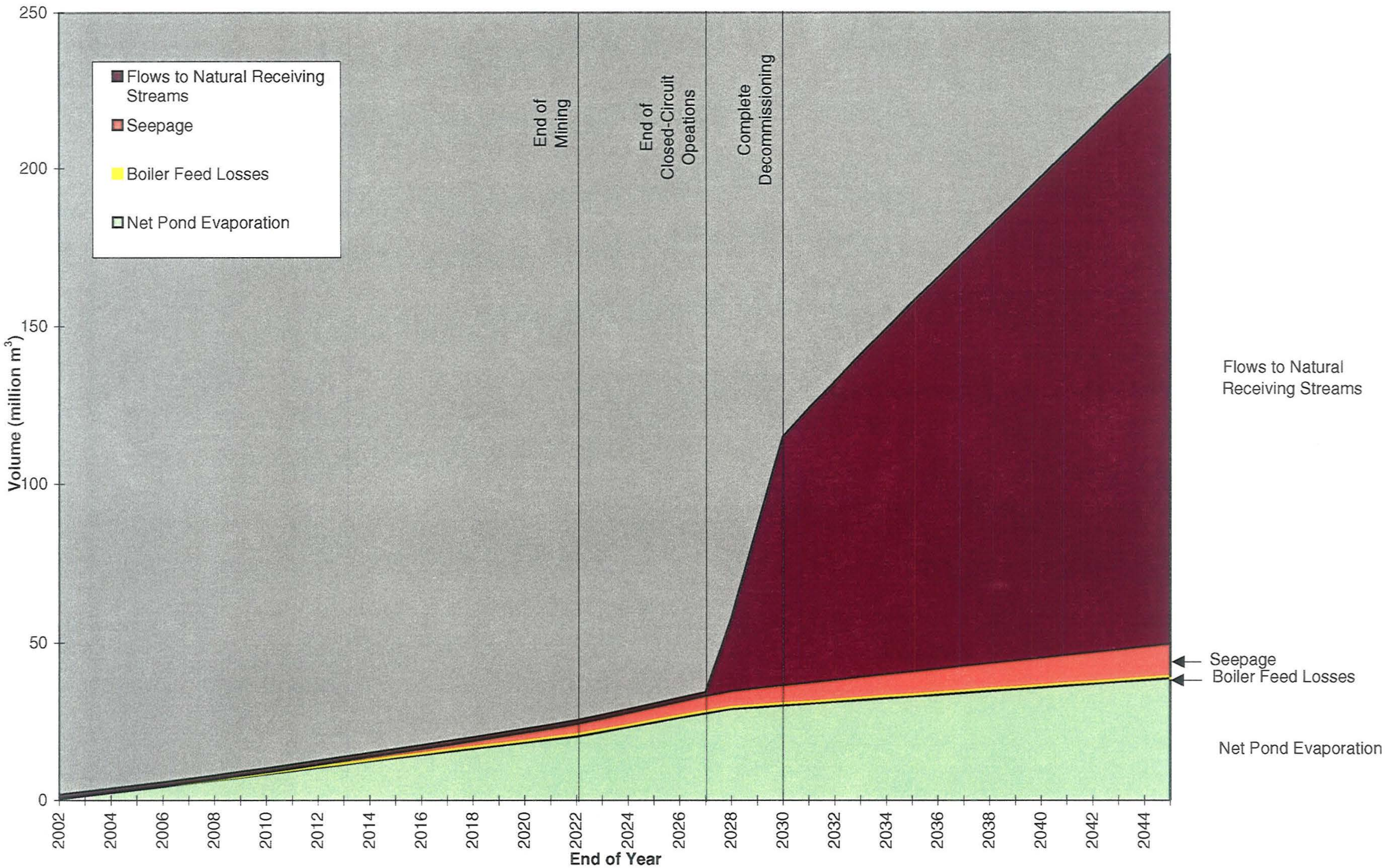
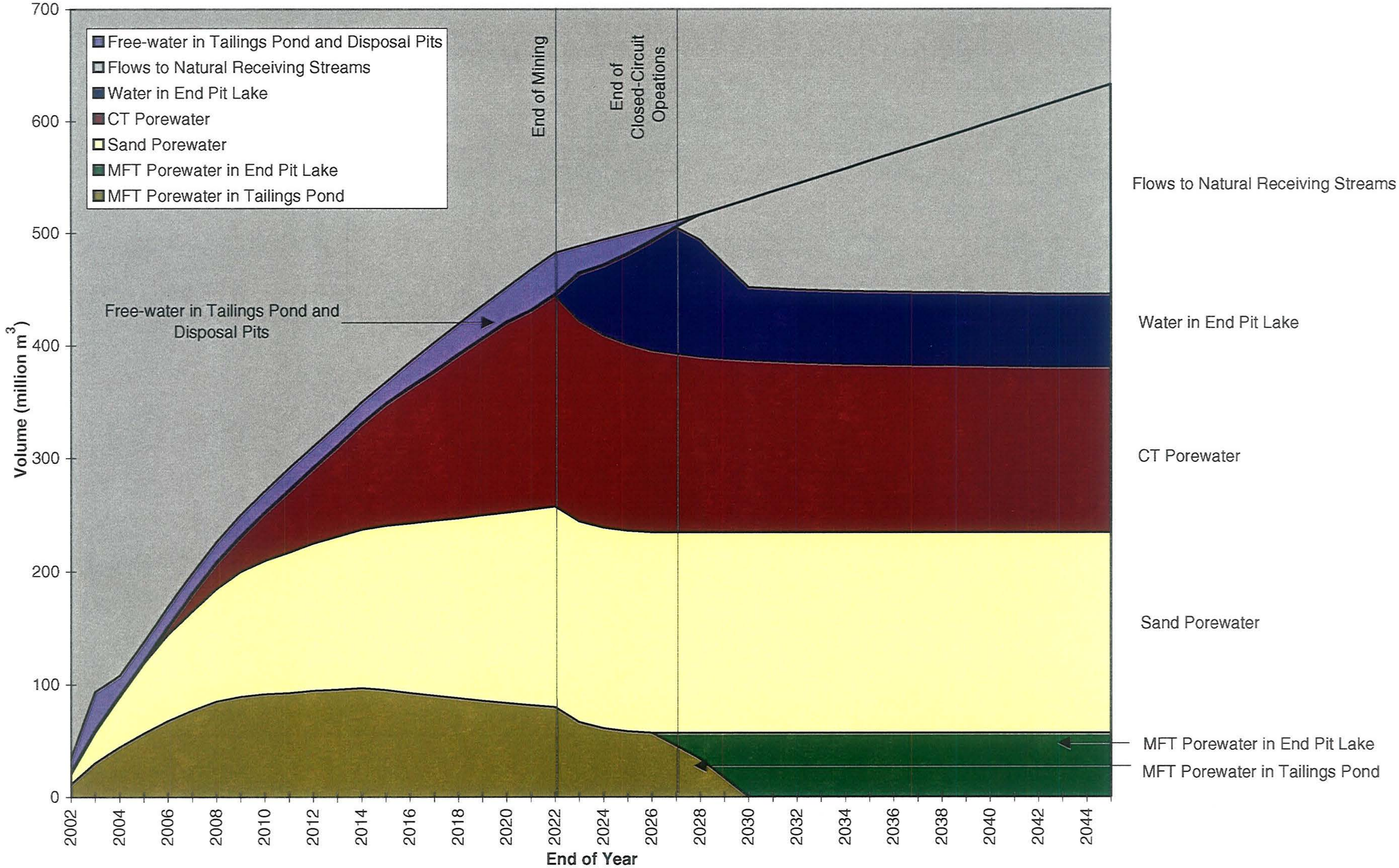


Figure 16
Inventory of Water at the Muskeg River Mine Project



4.2 Water Balance Inflows, Outflows and Changes in Storage After Mine Closure

At the end of mining in year 2023, approximately 17 million m^3 of water in the tailings water cap and 19 million m^3 of CT porewater in the pits will be transferred to the end-pit lake by pumping. The CT porewater must be removed from the mine pit area by pumping to the end-pit lake to enable construction of the final reclamation gravity-drainage system. Table 3 illustrates the water and MFT transfer schedule for the end-pit lake. During the five years after mine closure in 2022, the TFT remaining in the tailings pond will consolidate to approximately 66 million m^3 of MFT yielding an additional 22 million m^3 of free water which will need to be pumped to the end-pit lake. In addition, runoff and net rainfall on the tailings pond will also need to be pumped to the end-pit lake. The inventory of water will continue to increase until the end of closed-circuit operations in 2027. 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. After 2030, the inventory of water in the mine disturbed area will remain relatively constant and slow releases of CT porewater will occur until 2044.

Average annual inflows, outflows and changes in storage have been calculated for the operating phase of the mine from years 2002 to 2022. The results of this analysis are given on Figures 17 to 19 to provide a comparison of overall volumes and proportions. Water balance schematics have been developed to illustrate the relative magnitude of inflows, outflows and changes in storage during three separate years: (1) maximum intake requirements in year 2003 on Figure 20; (2) average intake requirements in year 2008 on Figure 21; and (3) minimum intake requirements in year 2022 on Figure 22. These diagrams have been constructed for three separate hydrologic scenarios, the 10 year wet period, average year and 10 year dry period.

4.3 Athabasca River Raw Water Withdrawals

Figure 23 illustrates the mean annual raw water withdrawal requirements from the Athabasca River for three separate hydrologic scenarios for a continuous sequence of 30 years: average conditions, wet period and dry period. As shown on the figure, changes in hydrologic conditions do not significantly affect the required withdrawals from the Athabasca River. The wet period

Figure 17
Mean Annual Inflows from 2002 to 2022
(3013 m^3/h)

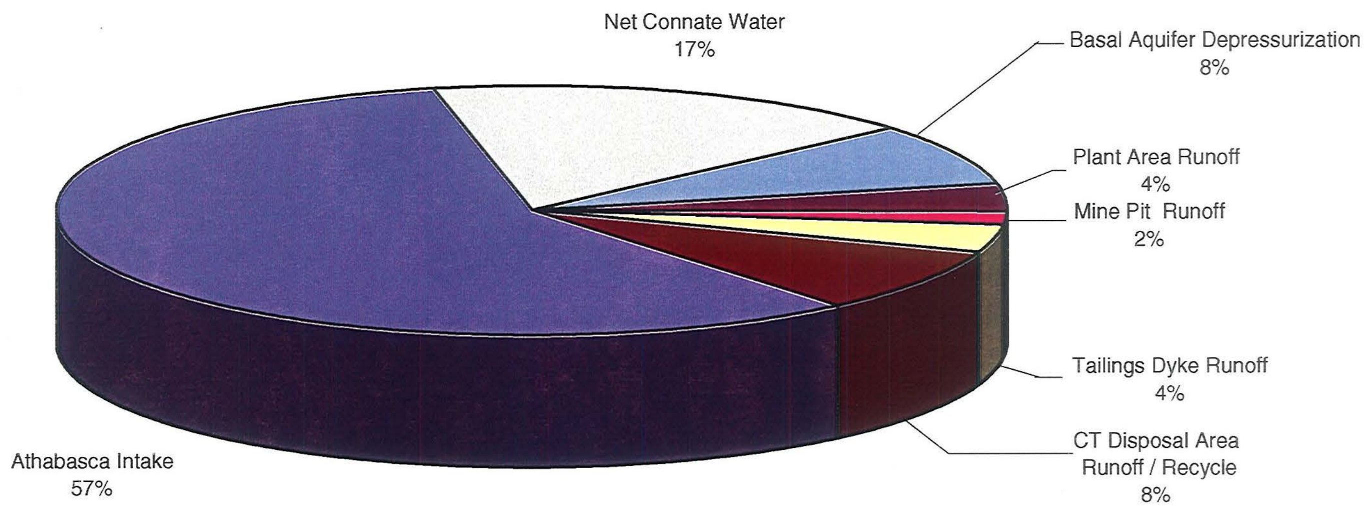


Figure 18
Mean Annual Outflows from 2002 to 2022
(136 m^3/h)

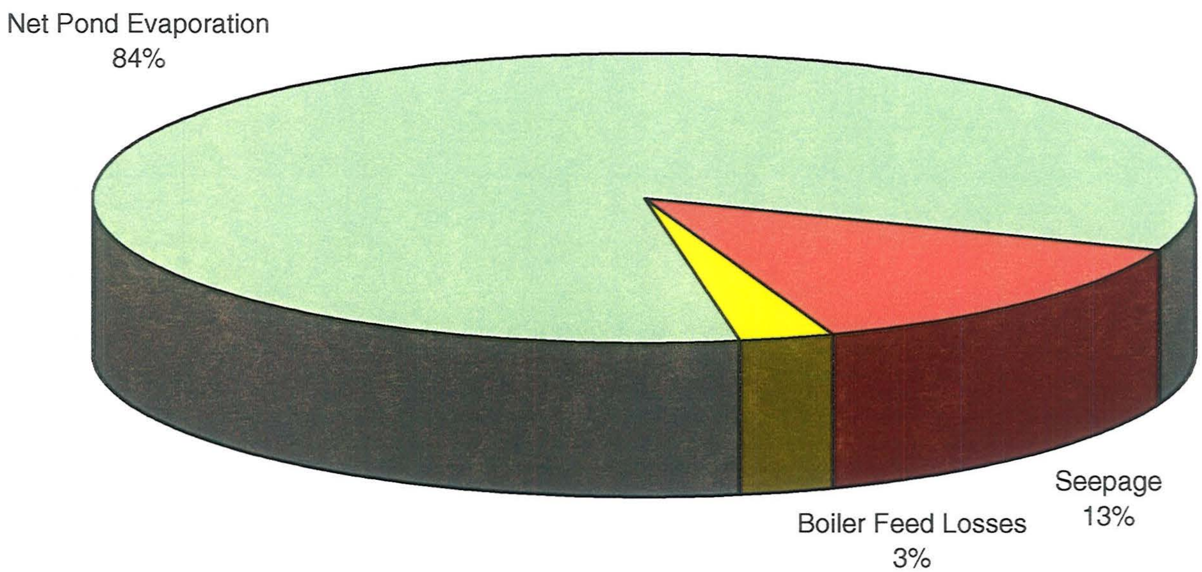
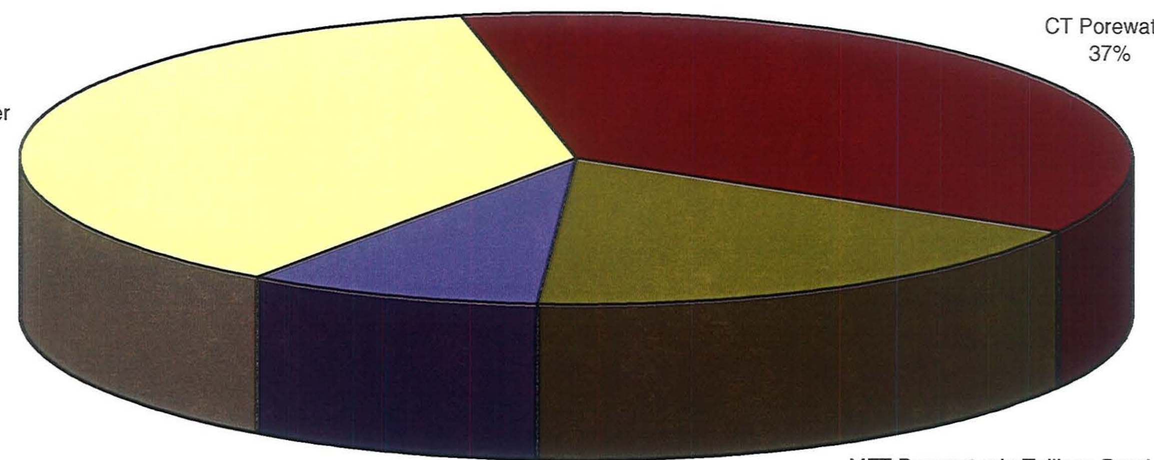
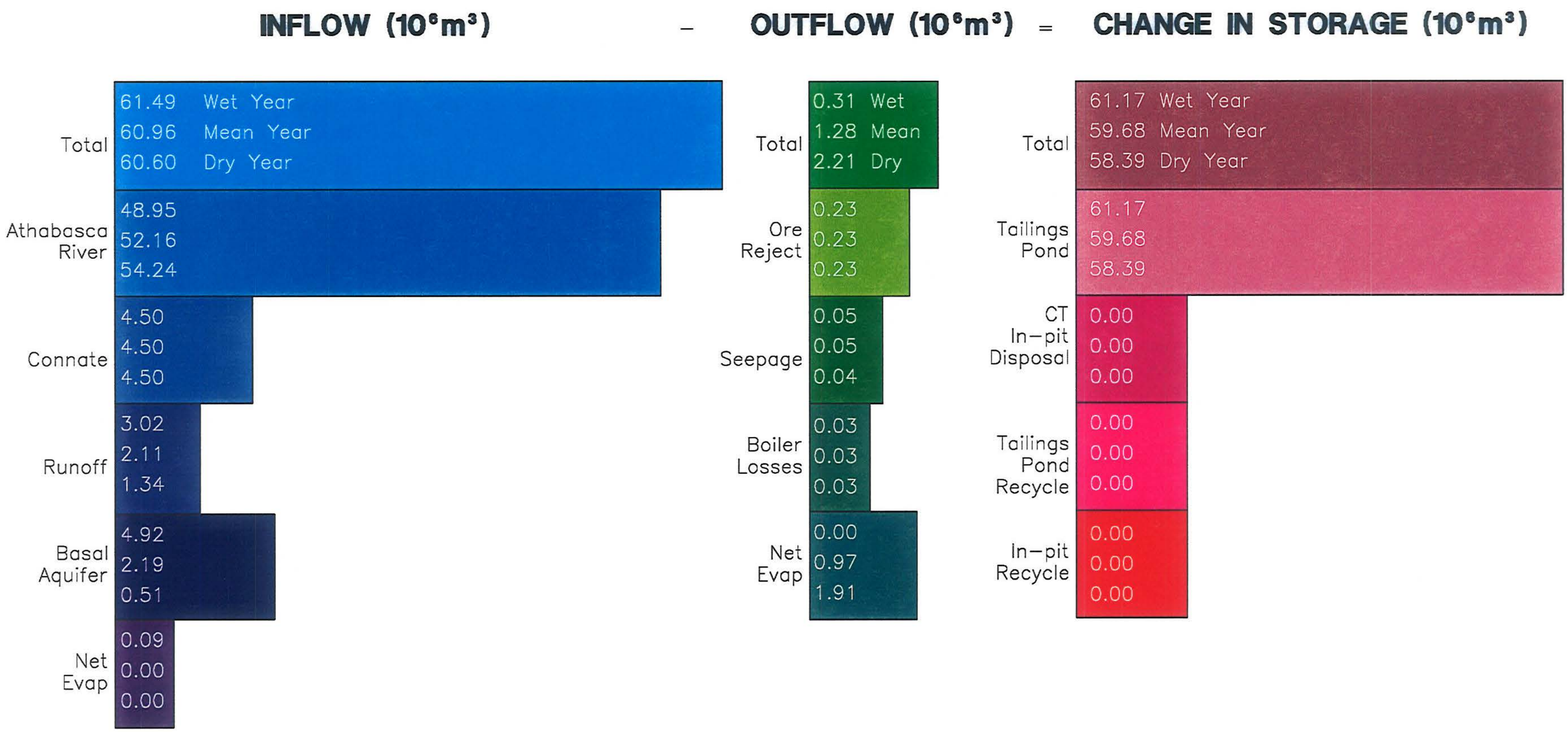


Figure 19
Accumulated Water in Storage by 2022
(481 million m^3)



J:\1997\2237\5092\graph3.DWG



NOT TO SCALE

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WATER BALANCE DURING YEAR 2003
MAXIMUM RAW WATER REQUIREMENTS

20 JAN 98	Figure No. 20	DRAWN BY: RFM

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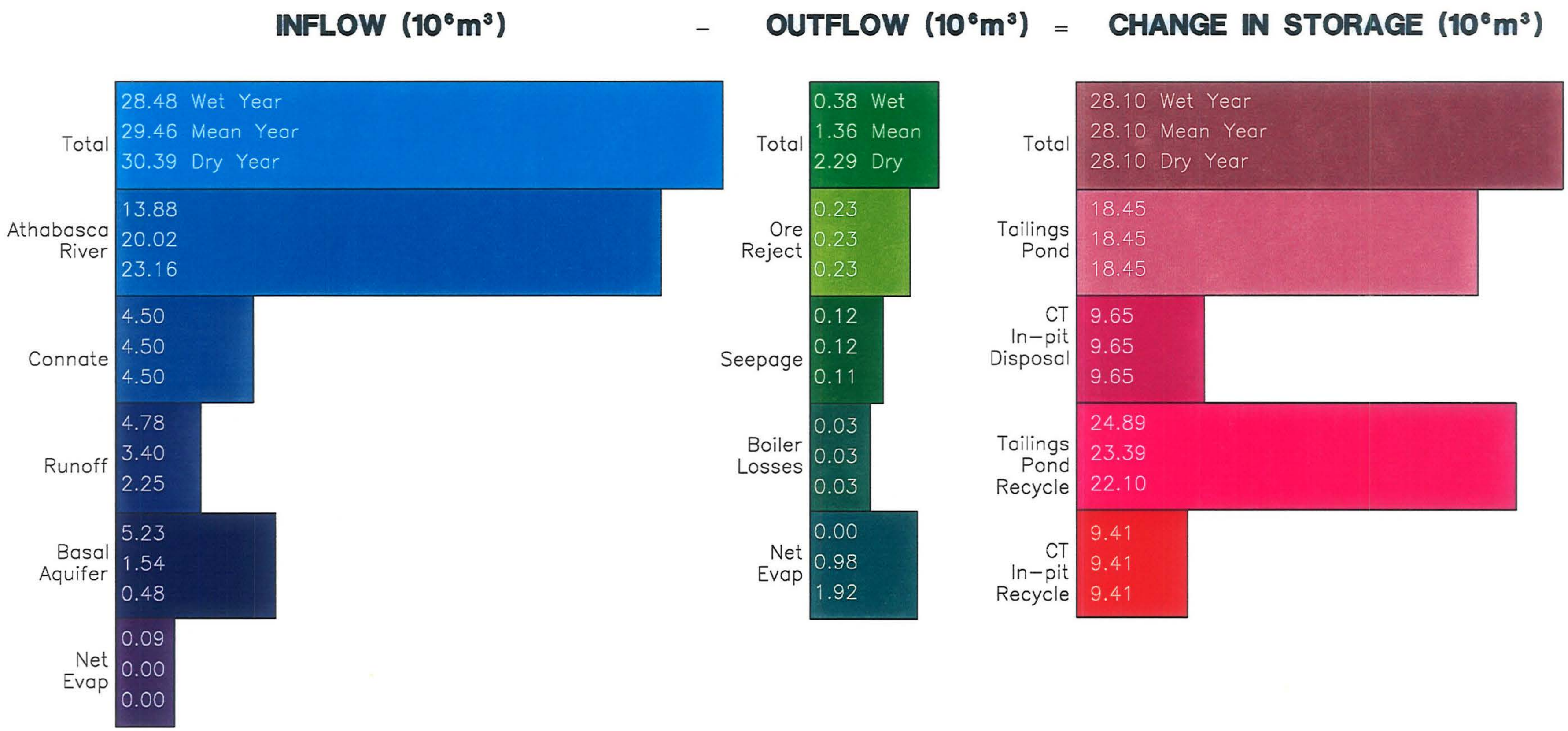

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WATER BALANCE DURING YEAR 2008
AVERAGE RAW WATER REQUIREMENTS

20 JAN 98	Figure No. 21	DRAWN BY: RFM

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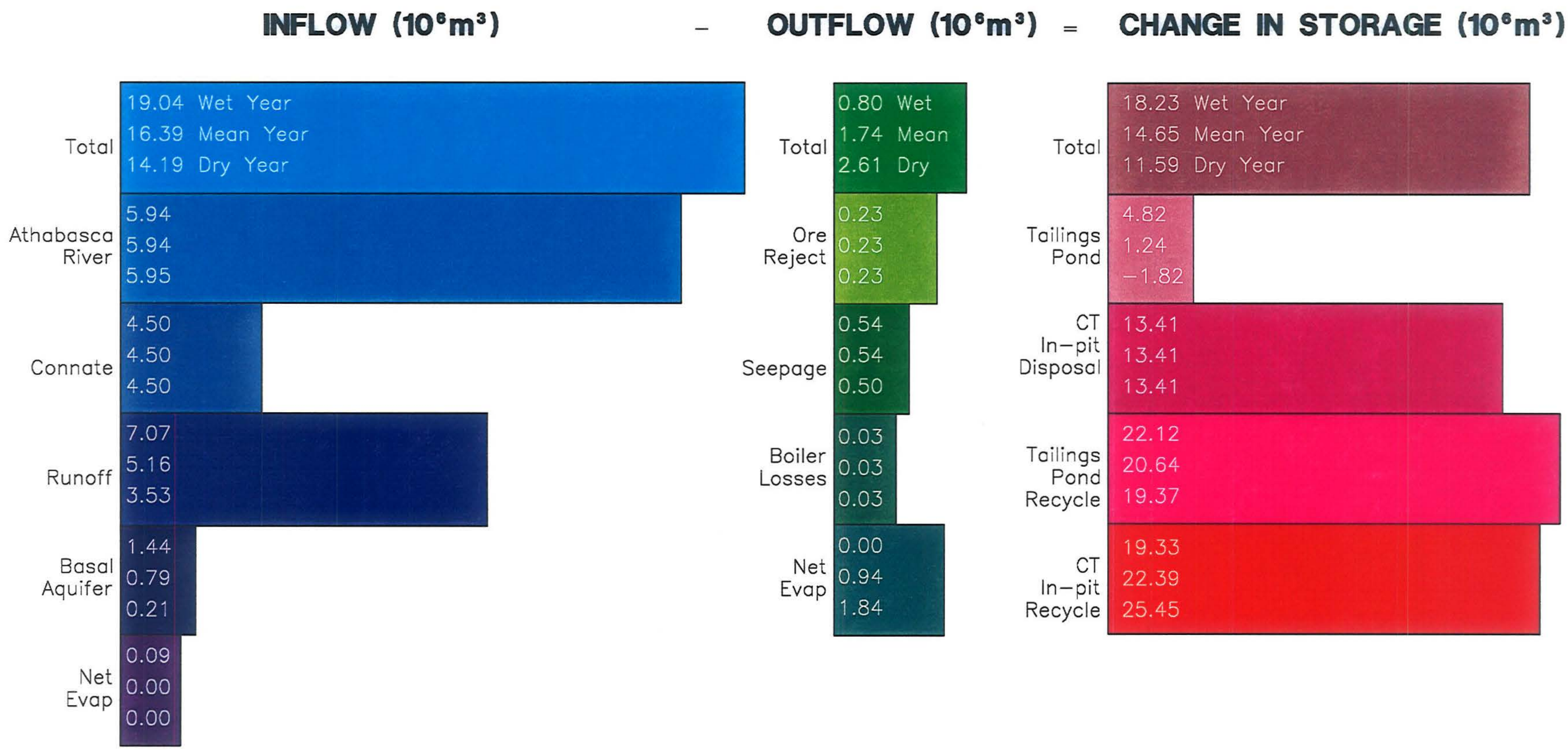

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WATER BALANCE DURING YEAR 2022
MINIMUM RAW WATER REQUIREMENTS

20 JAN 98	Figure No. 22	DRAWN BY: RFM

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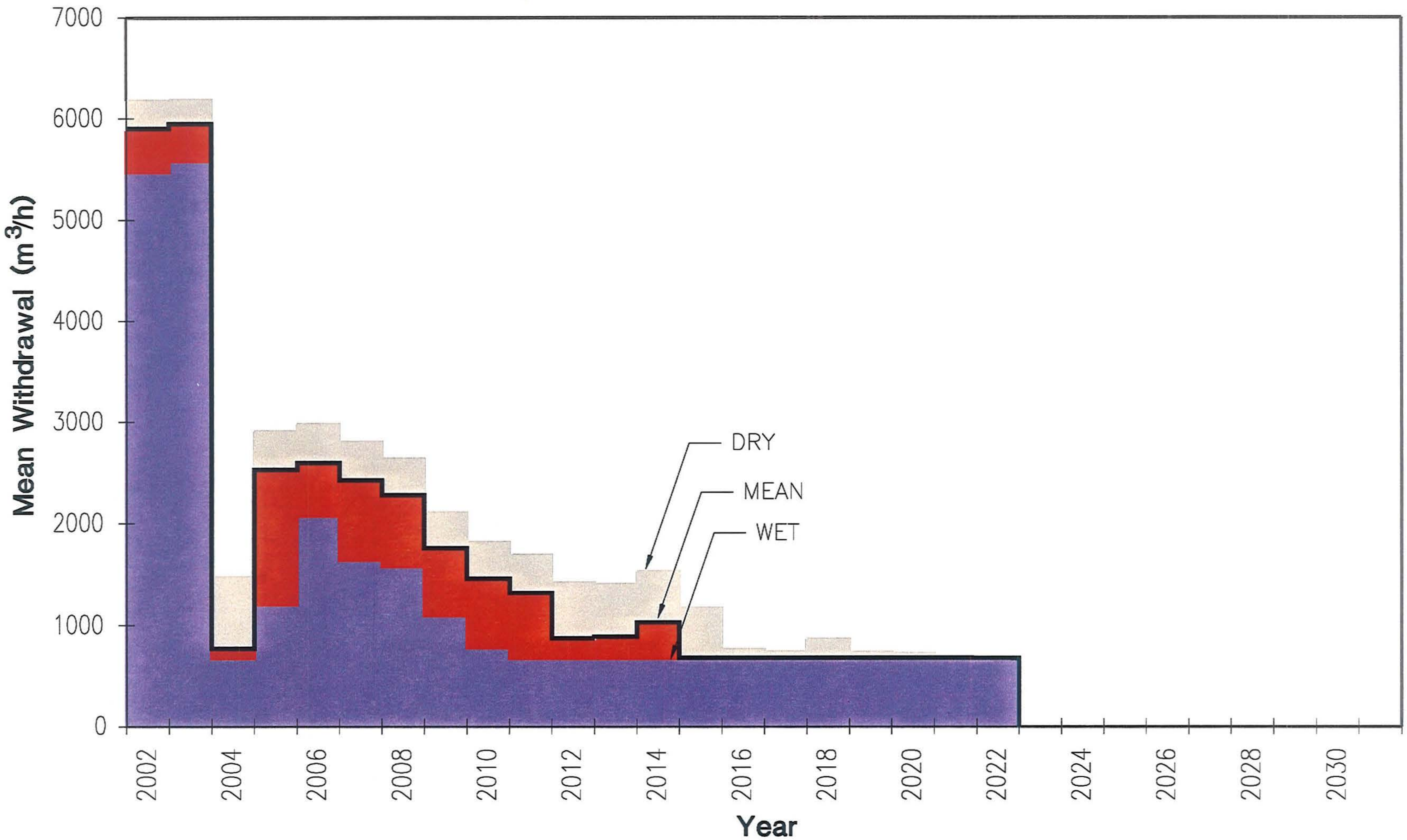

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MEAN ANNUAL RAW WATER REQUIREMENTS FOR THREE METEOROLOGICAL SCENARIOS (m^3/h)

21 JAN 98	Figure 23	DRAWN BY: TM

and dry period withdrawals represent extreme minimum and maximum conditions. To develop these scenarios, 10 year wet and dry conditions were assumed to occur each year, until the end of the mine life. The probability of this series of events occurring consecutively is extremely remote. The effect of wet and dry period occurrences is small during the first two years of maximum raw water withdrawals. The effects of hydrologic conditions become much more significant during the final years of mine operation. Hydrologic conditions will affect both the rate of Athabasca River withdrawals as well as the volume of excess free-water which may accumulate by the end of mining in year 2022.

The required average annual raw water supply varies from about 678 to 5,950 m^3/h for mean hydrologic conditions based on average annual per calendar day flows. The average annual raw water supply rate would vary up to 6284 m^3/h for dry period conditions and a modest (low-side) estimate of basal aquifer dewatering discharge. Peak short term raw water withdrawal rates (i.e., a few days duration) may be as high as 11,700 m^3/hr. The installed capacity of the pump station will be 9,000 m^3/h with three of four pumps operating, and a maximum capacity of 12,000 m^3/h with no pumps on standby.

4.4 Composition of Extraction Make-up Water

Figure 24 and Table 6 identify the sources of water for the extraction process. The makeup water supply has two major components: recycle water which is porewater that has been released from the MFT or CT, and raw water from the Athabasca River. These components vary in proportion to each other throughout the life of the mine. Other sources of water used for the extraction process include runoff from areas inside the closed-circuit operations, and water obtained from depressurizing the basal aquifer. These sources are included in the recycle water shown in Figure 24. Water released from consolidation of the CT accounts for approximately 5% of the CT produced and will be recycled and reused in the extraction process.

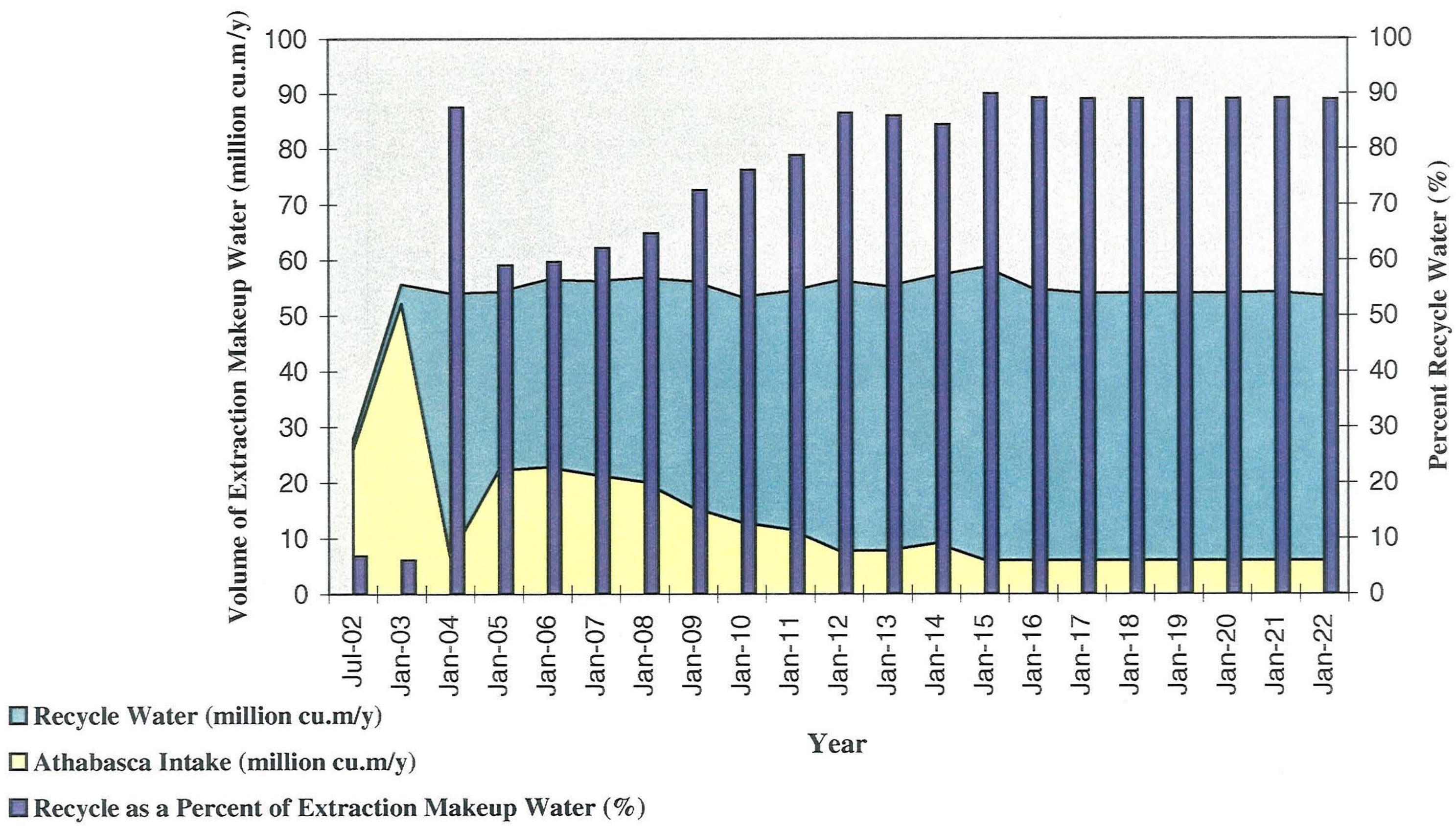
A large temporal variation in the annual raw water withdrawal rate from the Athabasca River will occur even though the total water requirements for the extraction process are relatively constant at approximately 55 million m^3 per year. Raw water requirements are at a maximum during the first two years of operation from 2002 to 2003 because the current tailings plan uses the conservative assumption that there is no recycle water from the thin fine tailings (TFT)

Table 6
Composition of Extraction Makeup Water
(million m^3)

Period Starting:	Recycle Water					Athabasca Intake	Total Makeup Water	Percent Recycle
	Net Runoff	CT Porewater Recycle and CT Pit Runoff	Basal Aquifer Depressurization	MFT Porewater Recycle and Tailings Pond Runoff	Total Recycle			
Jan-99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
May-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Nov-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
May-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Nov-01	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0%
Jul-02	0.5	0.0	1.4	0.0	1.9	25.9	27.7	7%
Jan-03	1.2	0.0	2.2	0.0	3.3	52.2	55.5	6%
Jan-04	1.4	0.0	1.9	43.9	47.2	6.8	53.9	87%
Jan-05	1.6	0.0	1.9	28.5	32.0	22.2	54.2	59%
Jan-06	1.9	5.0	1.9	24.8	33.6	22.8	56.4	60%
Jan-07	1.0	9.9	2.0	22.0	34.8	21.3	56.1	62%
Jan-08	1.0	10.8	1.5	23.4	36.7	20.0	56.7	65%
Jan-09	1.0	11.5	1.3	26.8	40.6	15.4	56.0	72%
Jan-10	1.1	15.9	1.3	22.2	40.5	12.8	53.3	76%
Jan-11	1.1	18.5	1.3	21.7	42.7	11.6	54.2	79%
Jan-12	1.2	21.0	4.0	22.4	48.6	7.6	56.2	86%
Jan-13	1.3	22.3	3.1	20.5	47.3	7.8	55.1	86%
Jan-14	1.3	22.8	2.7	21.2	48.1	9.0	57.1	84%
Jan-15	1.4	27.0	2.7	21.5	52.7	5.9	58.6	90%
Jan-16	1.5	26.1	2.7	18.4	48.7	5.9	54.7	89%
Jan-17	1.5	22.2	2.0	22.3	48.0	5.9	53.9	89%
Jan-18	1.6	22.7	1.6	22.2	48.0	5.9	53.9	89%
Jan-19	1.6	23.6	1.3	21.4	48.0	5.9	53.9	89%
Jan-20	1.7	24.5	1.3	20.4	48.0	5.9	53.9	89%
Jan-21	1.7	23.6	1.3	21.5	48.2	5.9	54.1	89%
Jan-22	1.7	24.3	0.8	20.6	47.5	5.9	53.4	89%
Jan-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

(data from AGRA, September 24, 1997)

Figure 24
Composition of Extraction Makeup Water



porewater release during this period. Raw water requirements are unusually low in 2004 because of the buildup of excess free-water during the initial two years of no recycle. The minimum free-water cap volume required for settling fines varies up to 19 million m^3. However, a total of 35 million m^3 accumulates after the initial two years of no recycle. The 17.5 million m^3 that exceeds the minimum tailings pond water cap volume in year 2004, will be used for recycle in the following year of operation. This explains why the raw water withdrawal from the Athabasca River is unusually small in year 2004.

The percentage of makeup water that is composed of recycle water is shown on Figure 24 for each year of mine operation. Initially, the percentage of recycle water is very low because recycle from the tailings pond is prohibited. Eventually, the portion of makeup water from the recycle operations rises to about 90%. At that time there is an equilibrium between the porewater release and the production of CT and MFT. A minimum withdrawal from the Athabasca River of about 6 million m^3 per year occurs after year 2014. This minimum raw water supply is necessary to supply the utilities plant with clean water for the potable, gland, utilities and boiler water streams.

4.5 Inventory of Free-Water

The total water inventory of free-water is not expected to exceed the minimum required volume during the first 14 years of operation. The occurrence of a wet year during the first 14 years of mining may result in the temporary availability of excess free-water but any excess will be recycled during subsequent drier periods. Storage of free-water will be limited to a 3 m water cap in the tailings pond amounting to 19 million m^3, plus minimum operating volumes in other operating ponds. Excess free-water will accumulate in the CT disposal areas in the mine pit area during the final seven years of mining. Approximately 19 million m^3 will accumulate by 2022 as a result of the release of porewater from CT. However, the CT porewater will not require additional storage capacity because it will accumulate above the CT surface in the space made available by consolidation.

A 10 year wet period was applied to the water balance analysis during the final year of operation (year 2022) to identify an extreme scenario when free-water storage requirements are at their maximum. This scenario is indicative of a high-side amount of excess free-water that may accumulate in the closed-circuit system. The 10 year wet period would cause an extra 2 million m^3 of free-water to accumulate in addition to 19 million m^3 of accumulated CT porewater stored in the pit area. This excess water cannot be decreased by reducing the import of raw water from the Athabasca River because a minimum rate of clean water is needed for plant utilities. Alternatives for reducing the excess free-water could include the following:

- release basal aquifer dewatering to natural receiving streams if the water quality is acceptable; and
- treat and release CT porewater to receiving streams.

4.6 Materials Mass Balance

A materials balance analysis, shown in Table 7, was prepared to provide an independent check on the water balance. The materials balance analysis is based on data received from AGRA Earth and Environmental and verifies a water balance accuracy of 0.2%.

4.7 Changes to Flow of Receiving Streams

Muskeg River

Development of the Muskeg River Mine Project will cause a net increase in the flows to the Muskeg River during mining and after closure. The size of the drainage basin of the Muskeg River will be reduced during mine operations by up to 34.5 km^2. This reduction results from development of the external tailings pond and the closed-circuit area of the mine pit area. This will cause a gradual reduction in the basin size and will decrease basin yield from the undisturbed area during mine operation. However, this decreased yield will be offset by discharges from muskeg drainage and overburden dewatering. Changes in Muskeg River flow resulting from mine operations will range from -0.4 m^3/s to 1.8 m^3/s through the life of the mine and during decommissioning.

Table 7
Material and Water Balance

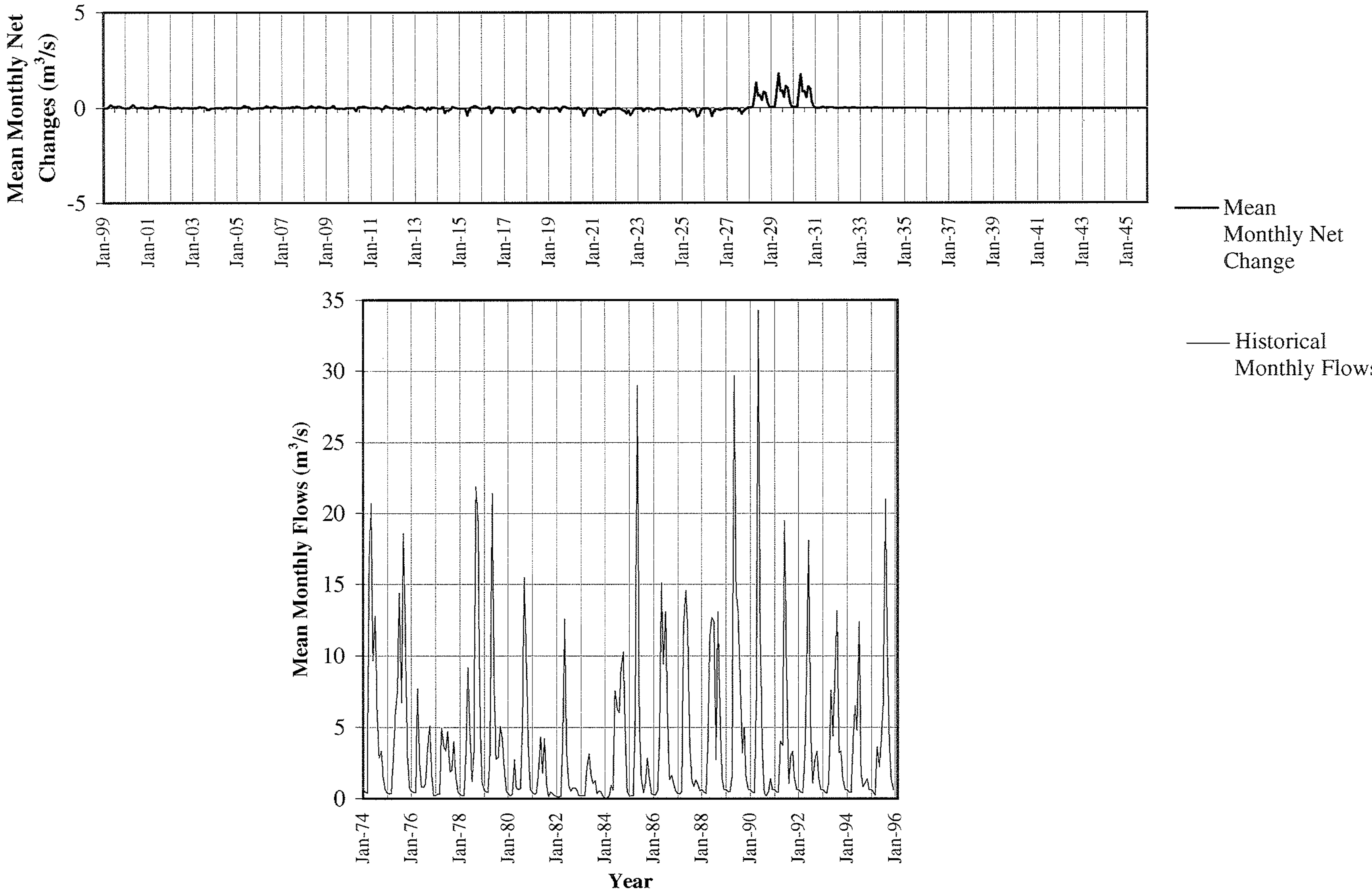
Component	Source	Total Mass million tonnes	Solids by Weight %	Water by Weight %	Bitumen by Weight %	Mass Solids million tonnes	Mass Water million tonnes	Mass Bitumen million tonnes
Inflows								
Ore	AEE	1817	84%	5%	11%	1517	93	207
Water	Water Balance	416	0%	100%	0%	0	416	0
Total		**2233**				**1517**	**509**	**207**
Outflows								
Ore	AEE	32	85%	14%	1%	27	4	0
Bitumen	AEE	207	0%	0%	100%	0	0	207
Water	Water Balance	26	0%	100%	0%	0	26	0
Total		**264**				**27**	**30**	**207**
Storage								
CT	AEE	985	81%	19%	0%	798	187	0
MFT	AEE	99	21%	79%	0%	21	79	0
Sand	AEE	843	79%	21%	0%	665	178	0
Free-Water	Water Balance	36	0%	100%	0%	0	36	0
Total		**1964**				**1484**	**480**	**0**
Error in Balance		**5**				**6**	**-1**	**0**
		0.2%				0.4%	-0.2%	0.0%

The net changes in the monthly flows of the Muskeg River are illustrated in the upper graph on Figure 25. For comparison purposes, the historical Muskeg River flow record from 1974 to 1995 is shown on the lower graph along with the future changes (from pre-construction drainage in 1999 to the end of decommissioning in 2045) that are shown on the upper graph.

The maximum decrease in the Muskeg River flows is 0.4 m^3/s based on mean annual water yields of 0.085 m/y. This change will occur during the final period of mining when the size of the closed-circuit operations is at a maximum (approximately 34.5 km^2). A significant net increase (1.8 m^3/s) in the river flows will occur during the initial years of mine closure when additional water is released as a result of water accumulated during closed-circuit operations.

The maximum increase in the flow of the Muskeg River is 1.8 m^3/s. This is equivalent to 640% of the 7Q10 natural flow of 0.28m^3/s. However, the quality of water released will be below toxic levels so that this increase is not critical. Since 1.8 m^3/s is only 11% of the mean monthly

Figure 25
Net Impacts on Muskeg River Flow



maximum flow of 16.4 m^3/s (based on records from 1974 to 1995) morphologic impacts are not expected to be significant.

Athabasca River

The effects of mine development on Athabasca River flows will be essentially undetectable. Changes in Athabasca River flows will occur as a result of the combined effects of water withdrawal for processing and a net change in the discharges from the Muskeg River basin. The net changes in flow resulting from these two impacts are plotted on Figure 26 on the upper graph. For comparison, the historical flow record for the Athabasca River from 1965 to 1992 is shown on lower graph. Note that the vertical scale on the upper graph has been exaggerated 100 times. The most significant change is the withdrawal of water at a rate of approximately 1.75 m^3/s during the first two years of operation (2002 and 2003). This withdrawal rate represents only 2% of the extreme minimum recorded daily low-flow in the Athabasca River of 89 m^3/s, during a recording period of 28 years. The 1.75 m^3/s maximum Athabasca River withdrawal rate is only 1% of the minimum monthly mean flow of 163 m^3/s and only 0.3% of the mean annual flow of the river (652 m^3/s).

A comparison of proposed raw water withdrawal rates with the Athabasca River flow duration curve and recorded monthly flows is given on Figures 27 and 28. These figures show that the proposed withdrawal rates are very small compared with the river flows, even during periods of low flow.

Athabasca River withdrawals by each of the existing and planned oil sands developments, as well as other users within the basin, are shown in Table 8. There is no return flow indicated for the oil sands developments because they are all essentially closed-circuit operations during the mine operations. Return flows for the other non-oil sands operations have been considered in the calculations. The maximum (licensed) river withdrawal for oil sands projects of 7.6 m^3/s is 7.6% of the minimum recorded monthly flow of 101 m^3/s and 4.7% of the lowest mean monthly flow of 163 m^3/s which occurs in February. These are total withdrawal rates, not including return flows.

Figure 26
Net Impacts on Athabasca River Flow

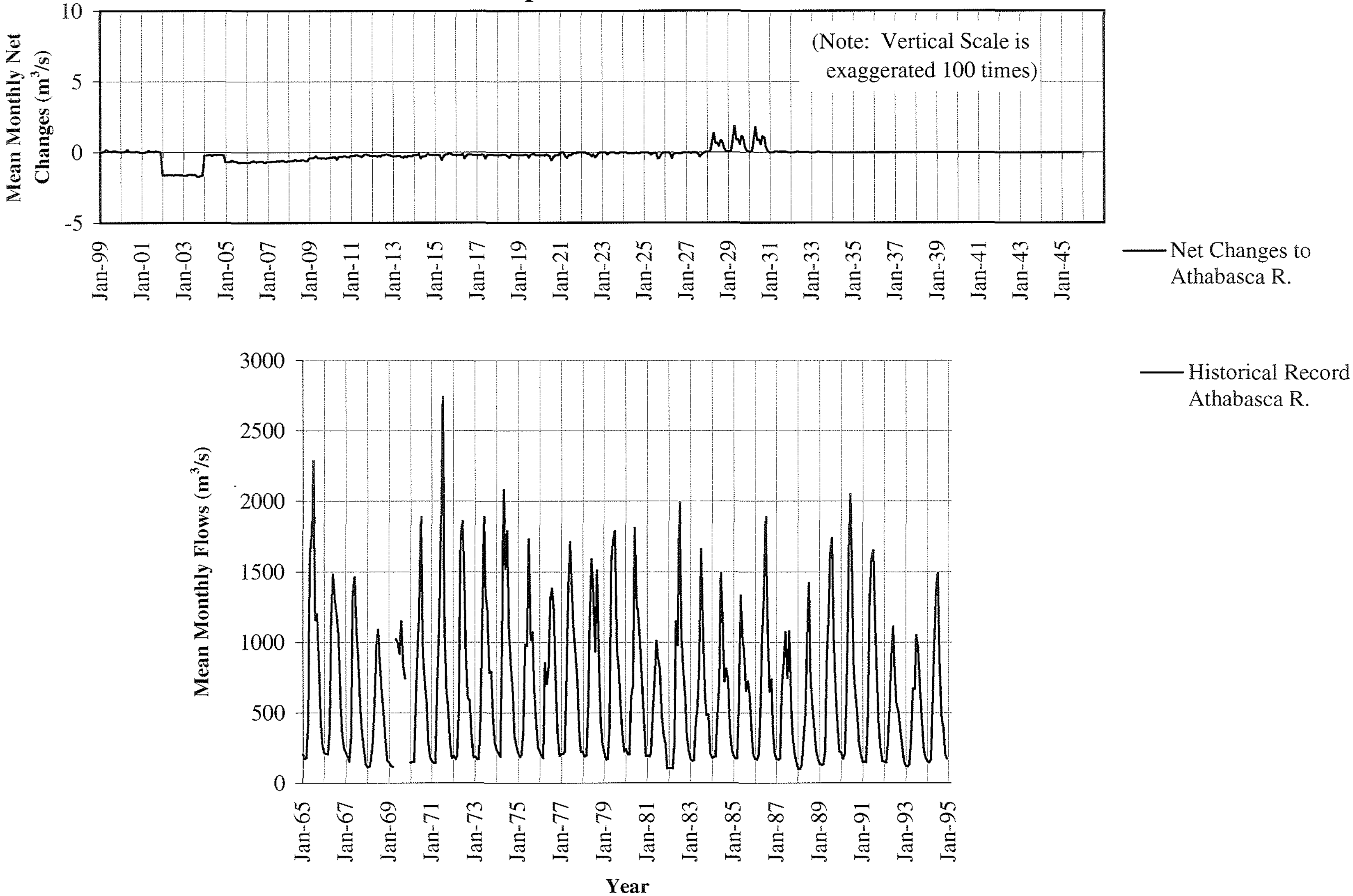


Figure 27
Athabasca River Flow Duration Curve

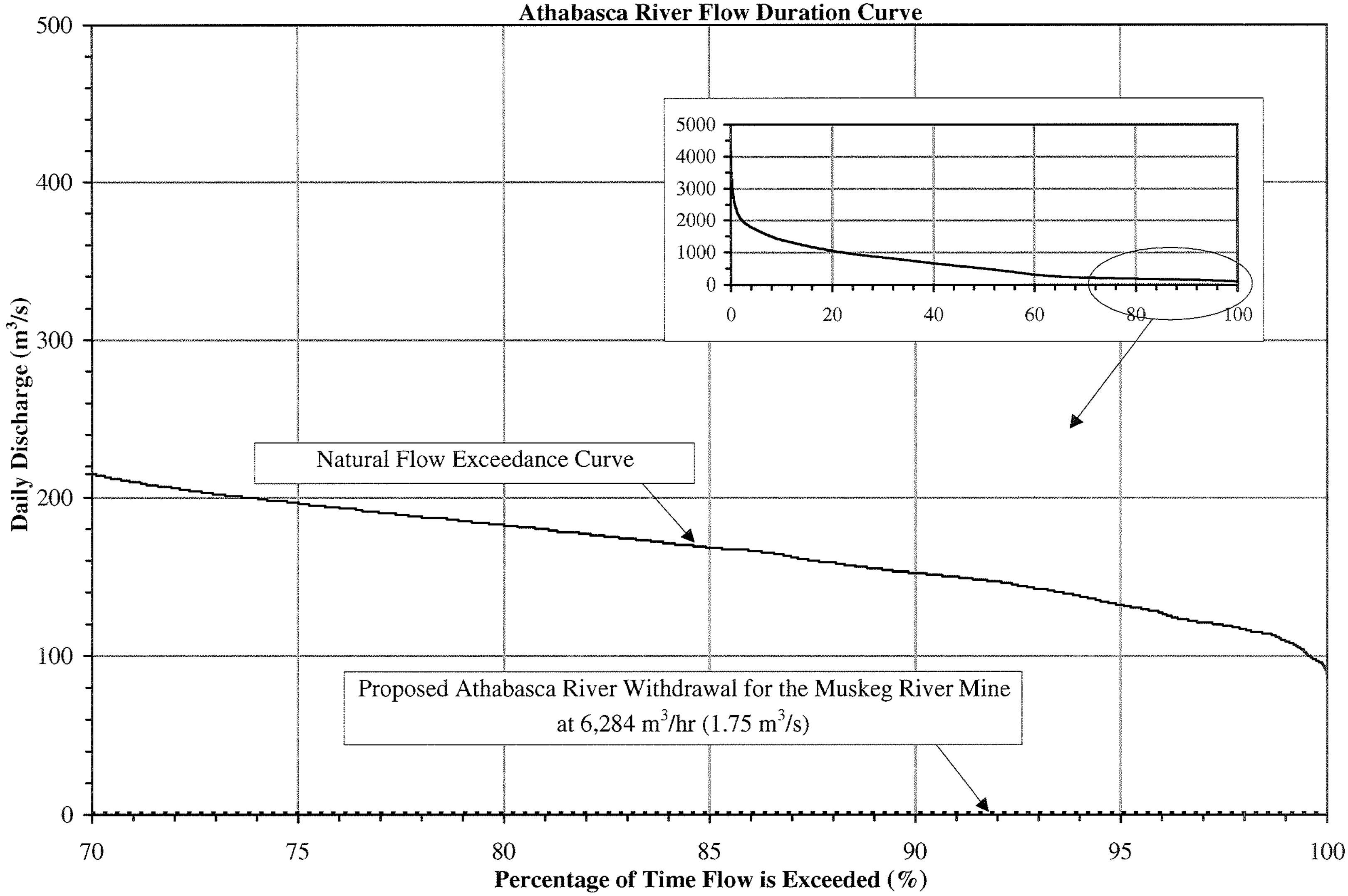


Figure 28
Athabasca River Monthly and Daily Flows

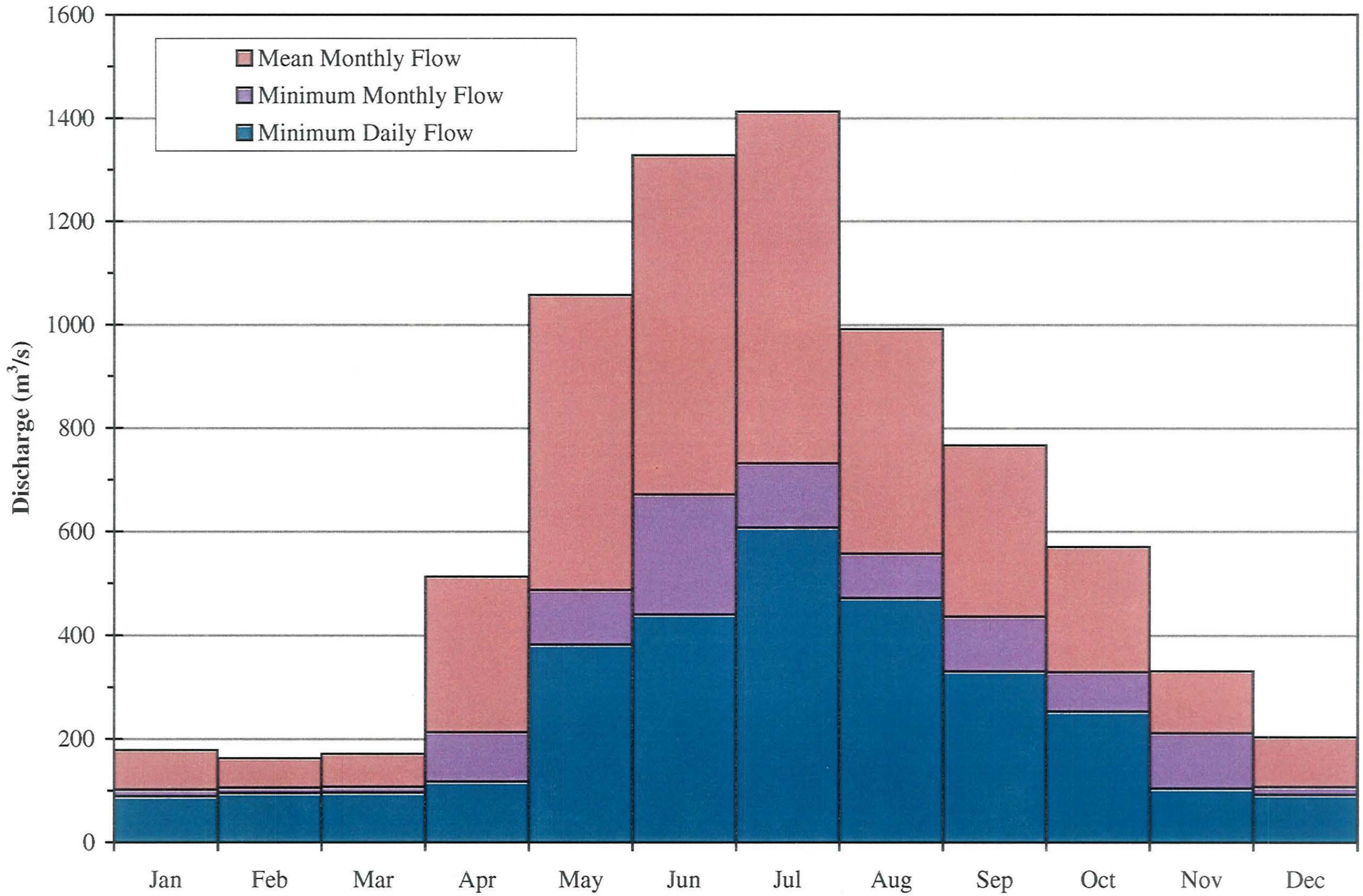


Table 8
Licensed Withdrawals from the Athabasca River Basin

DEVELOPMENT	EXISTING AND PROPOSED LICENSED RIVER WITHDRAWAL	
	VOLUME million m^3 / year	**MEAN FLOW** m^3/s
Existing or Interim Licenses		
Syncrude [1]	68.0	2.2
Suncor [2]	59.8	1.9
Solv-Ex [1]	5.0	0.2
Proposed Licenses		
Shell - Muskeg River Mine Project West and East [3]	55.1	1.8
Suncor - Millennium Mine [4]	0	0
Syncrude - Aurora North and South Mines [5]	0	0
Mobil [6]	47.8	1.5
Sub-Total	**235.7**	**7.6**
Non-Oil Sands Development		
Proposed and Existing Licenses [1]	267.7	8.4
Grand Total	**503.4**	**16.0**

1 From the Water Administration Branch, NEB. September 1997.
2 From the Water Administration Branch, NEB. September 1997. As a conservative assumption, return flows from the Suncor operation have been neglected.
3 From the Mine Water Management Plan for Shell's Muskeg River Mine Project, Golder Associates. November 1997. It has been assumed that peak withdrawals for the West and East mines will not occur simultaneously. In addition, it has been assumed that the water withdrawals required for processing ore from the East Mine will be within the license proposed for the West Mine.
4 Withdrawal requirements for the Steepbank/Millennium Mines will be within Suncor's existing license.
5 Withdrawal requirements for processing ore from the Aurora Mine will be within Syncrude's existing license.
6 Estimated by prorating the average licensed withdrawal per daily production capacity for the proposed Muskeg River Mine Project (150,000 barrels per day) to the Mobil lease (100,000 barrels per day).

The maximum allowable licensed river withdrawals do not represent normal conditions. For example, average Athabasca River water withdrawals by Shell during the 20-year mine life would be only 48% of the proposed licensed withdrawal rate, equal to about 0.8 m^3/s. The peak water withdrawal by Shell would last for a period of only two years after which the withdrawal rates would be significantly smaller. Both Syncrude and Suncor experience similar variations in water withdrawals during their mining operations. Filling Aurora's end-pit lakes, will be done during the high-flow season from June to September and therefore will not affect low flows of the Athabasca River. The peak water demands during the initial years of operation of the various oil sands mines are unlikely to coincide because the developments are staggered in time. Therefore, the mean water withdrawal through the mine life is a more reasonable basis for assessing impacts to the Athabasca River.

Based on a 0.5 ratio of average river withdrawal to licensed river withdrawal for the oil sands operations, the combined river withdrawals of existing and planned projects (3.5 m^3/s), and non-oil sands operations (0.9 m^3/s) would be about 4.4 m^3/s. This is only 4.4% of the minimum recorded monthly flow of 101 m^3/s, and 2.7% of the lowest mean monthly flow of 163 m^3/s on the Athabasca River. Differences in discharge rates of this order would not likely be detectable.

5. WATER QUALITY OF PROCESS STREAMS

CANMET completed a detailed study of the water quality of various process streams. The results of this study are presented in their October 7, 1997, report and summarized in Table 9. Ranges of concentrations of ions are given for the major streams including water supply, recycle water, ore connate water, CT porewater and sand porewater. The results on Table 9 represent a worst case scenario based on the following assumptions:

- surface water runoff is similar to Athabasca River water; and
- the water quality of discharge from surficial aquifers is similar to the basal aquifer.

Table 9
Water Quality of Process Streams

			Ion Concentration (mg/L)							
		pH	**H_{CO3}**	**Ca**	**Na**	**K**	**Mg**	**Cl**	**SO_4**	**TDS**
Athabasca River[1]	Typical	7.75	130	32	13	1	10	11	22	219
Connate[1]	Worst Case	7.60	1670	31	1120	310	15	870	110	4126
	Typical	7.46	540	4	270	50	4	130	40	1038
Recycle[1] (after 14 years)	Worst Case	n/a	879	84	531	146	12	429	1917	3998
	Typical	n/a	329	81	133	24	7	69	1883	2527
Basal Aquifer[2]	High	8.6	n/a	n/a	n/a	n/a	n/a	2793	90	7404
	Low	7.4	n/a	n/a	n/a	n/a	n/a	81	3	815
Surficial Aquifer[2]	High	7.9	n/a	n/a	n/a	n/a	n/a	134	300	1729
	Low	6.7	n/a	n/a	n/a	n/a	n/a	1.6	2	249
Surface Water[3]	Muskeg River (1997)	7.7	313	67	14	1.6	18	5.5	6	270

Notes: 1. CANMET report, October 7, 1997
2. Komex letter, August 26, 1997
3. GAL report, 1997

These results indicate that even after 20 years of mine operation, water chemistry and quality will not be a concern for tailings operation and extraction. Future work will be necessary to assess the feasibility of treating and releasing some process streams.

6. FENCELINE BOUNDARIES

Fenceline boundaries enclosing the proposed disturbed area are shown on Figure III-1 in Appendix III. The fenceline boundary location has been selected to enclose all facilities associated with the Muskeg River Mine Project.

7. CLOSURE

This report presents a detailed description of the mine water management plan for the Muskeg River Mine Project 150,000 barrels per calendar day production scenario, sufficient for purposes of the EIA.

GOLDER ASSOCIATES LTD.

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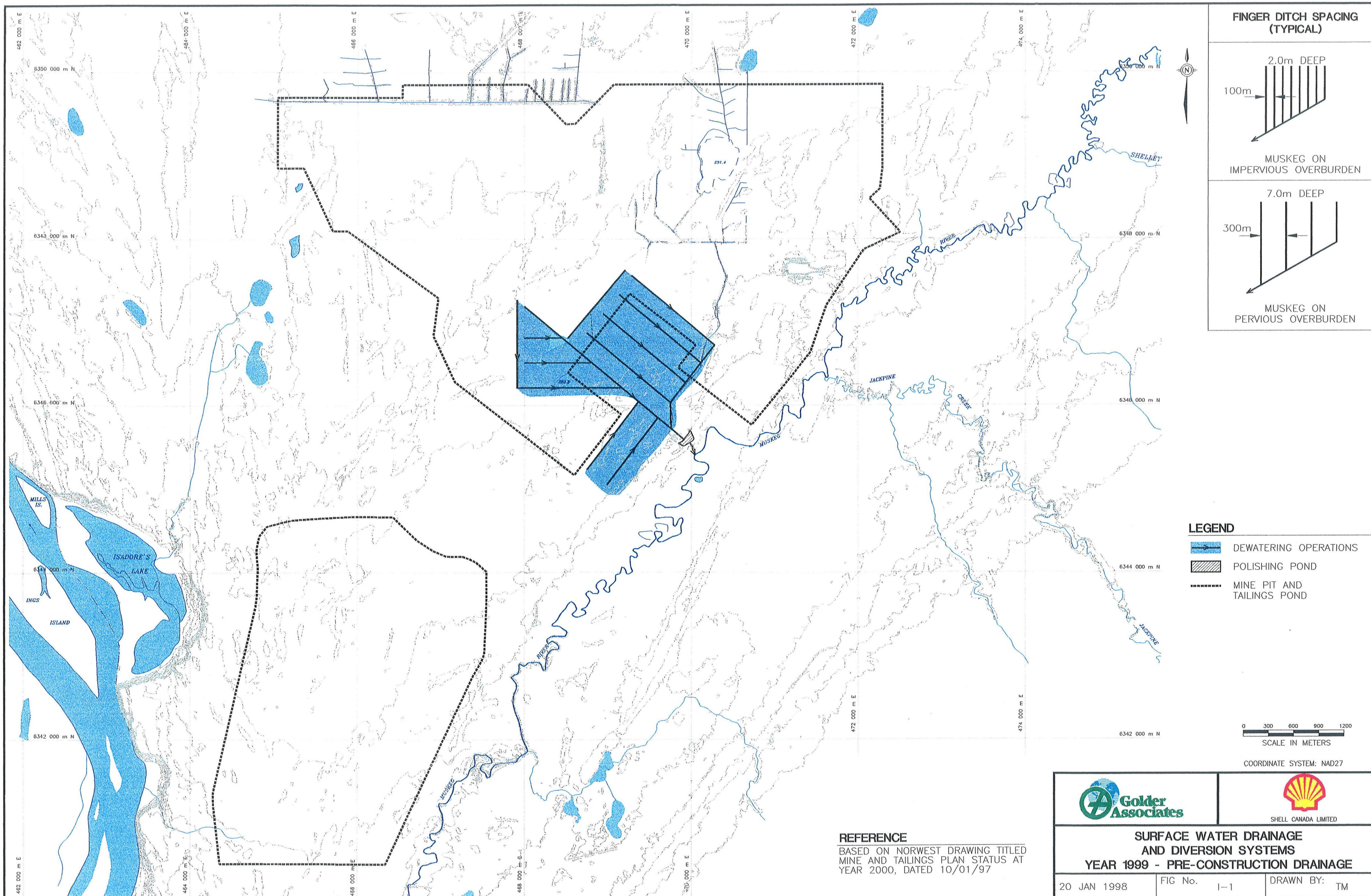
APPENDIX I

SURFACE WATER AND DIVERSION SYSTEMS THROUGH MINE LIFE

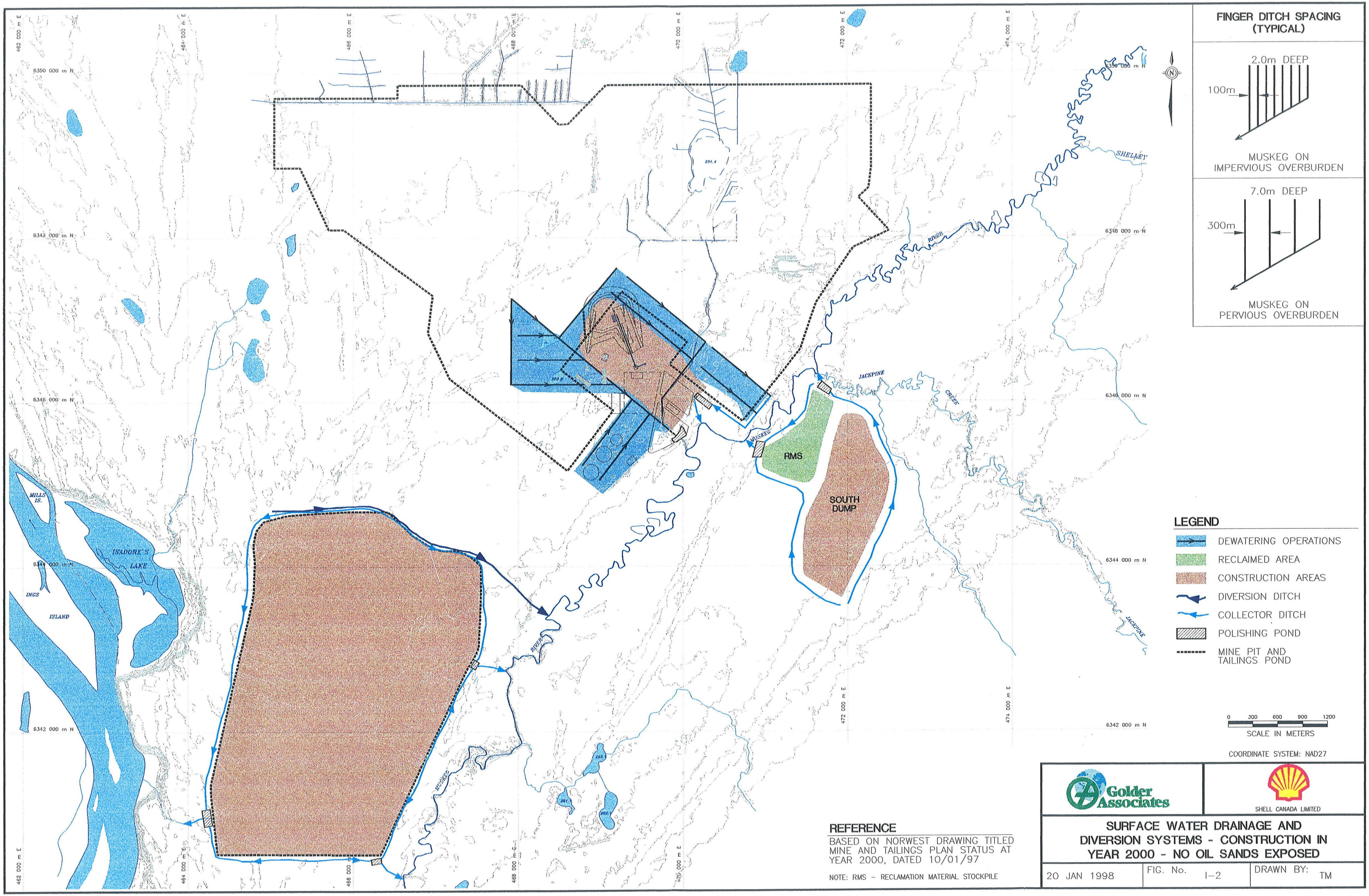
LIST OF FIGURES



SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS
YEAR 1999 - PRE-CONSTRUCTION DRAINAGE

20 JAN 1998	FIG No. I-1	DRAWN BY: TM

J:\1997\2237\5092\YEAR1999.DWG



REFERENCE

BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97

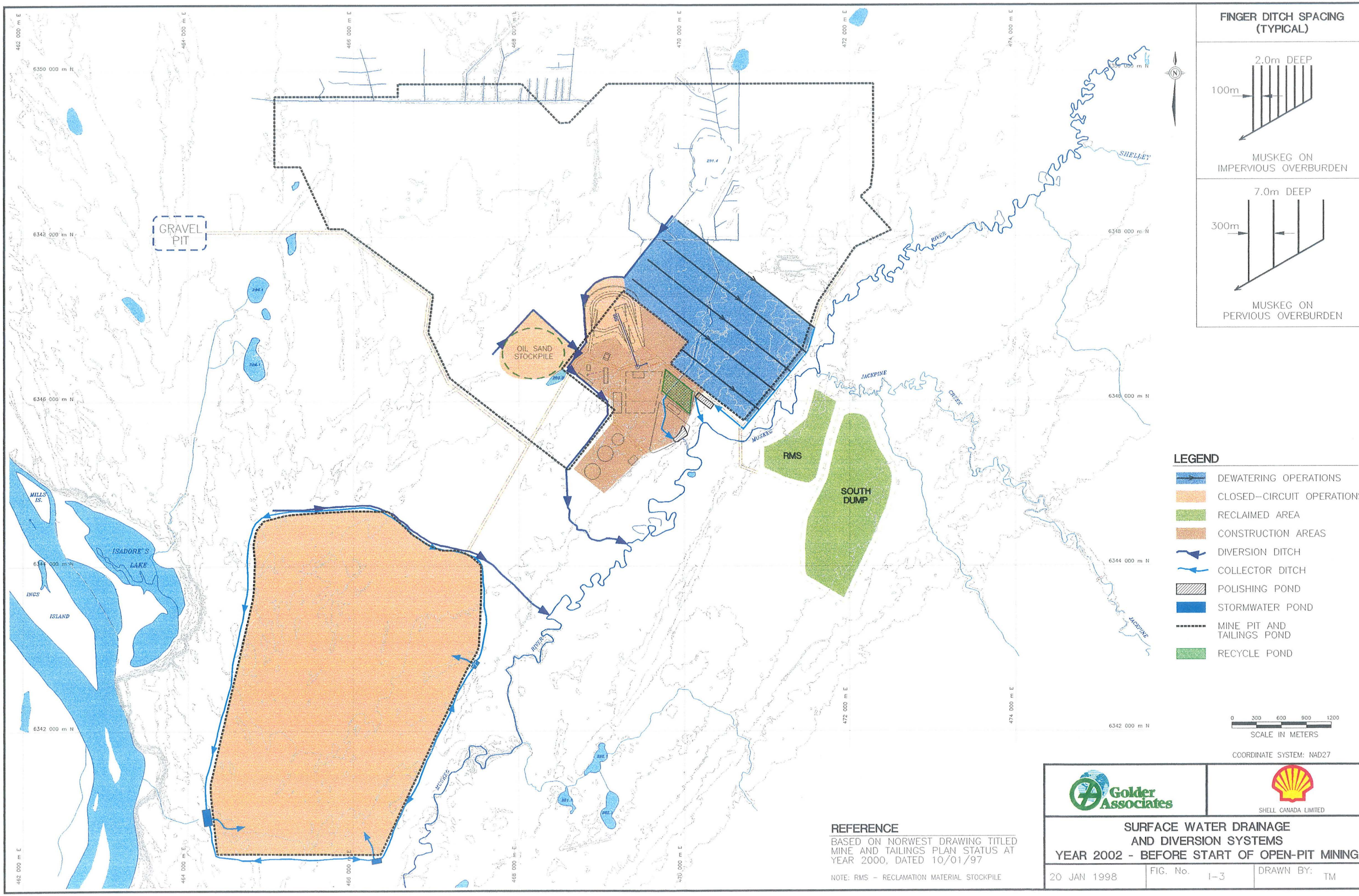
NOTE: RMS – RECLAMATION MATERIAL STOCKPILE

Golder Associates

SHELL CANADA LIMITED

SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS – CONSTRUCTION IN YEAR 2000 – NO OIL SANDS EXPOSED

20 JAN 1998	FIG. No. I-2	DRAWN BY: TM


J:\1997\2237\5092\YEAR2002.DWG
FINGER DITCH SPACING (TYPICAL)
2.0m DEEP
100m
MUSKEG ON IMPERVIOUS OVERBURDEN
7.0m DEEP
300m
MUSKEG ON PERVIOUS OVERBURDEN
GRAVEL PIT
OIL SAND STOCKPILE
RMS
SOUTH DUMP
SHELLEY
RIVER
JACKPINE
CREEK
MUSKEG
MILLS IS.
ISADORE'S LAKE
INGS ISLAND
LEGEND
DEWATERING OPERATIONS
CLOSED-CIRCUIT OPERATIONS
RECLAIMED AREA
CONSTRUCTION AREAS
DIVERSION DITCH
COLLECTOR DITCH
POLISHING POND
STORMWATER POND
MINE PIT AND TAILINGS POND
RECYCLE POND
SCALE IN METERS
0 300 600 900 1200
COORDINATE SYSTEM: NAD27
REFERENCE
BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97
NOTE: RMS - RECLAMATION MATERIAL STOCKPILE
Golder Associates
SHELL CANADA LIMITED
SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS
YEAR 2002 - BEFORE START OF OPEN-PIT MINING
20 JAN 1998
FIG. No. I-3
DRAWN BY: TM

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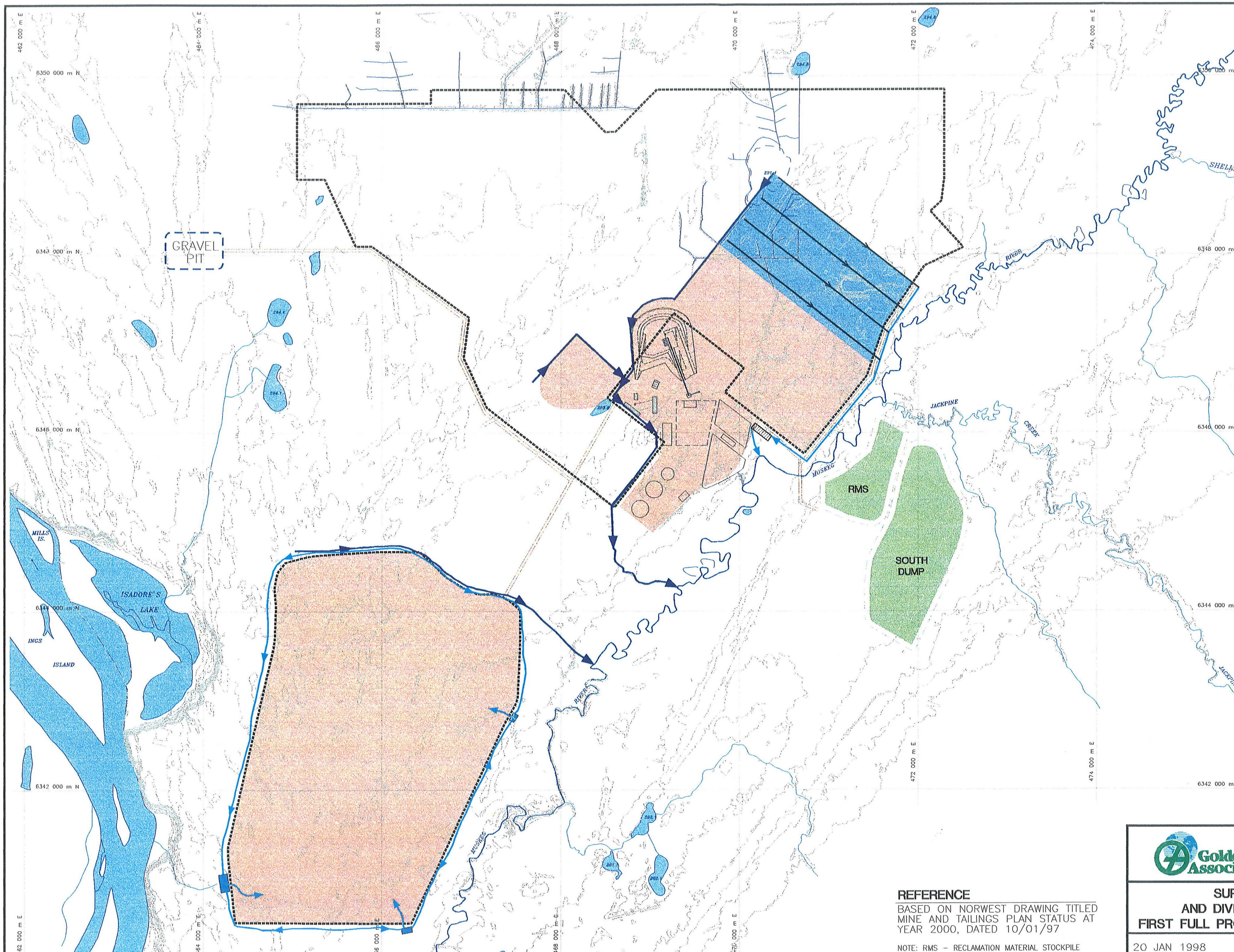
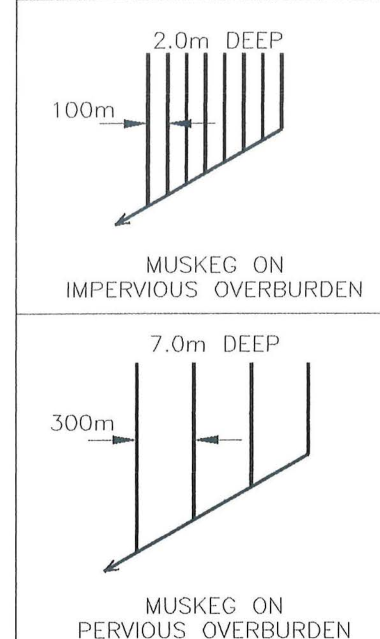


FINGER DITCH SPACING (TYPICAL)



LEGEND

- DEWATERING OPERATIONS
- CLOSED–CIRCUIT OPERATIONS
- RECLAIMED AREA
- DIVERSION DITCH
- COLLECTOR DITCH
- POLISHING POND
- STORMWATER POND
- MINE PIT AND TAILINGS POND

0 300 600 900 1200
SCALE IN METERS

COORDINATE SYSTEM: NAD27

REFERENCE

BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97

NOTE: RMS – RECLAMATION MATERIAL STOCKPILE

Golder Associates

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SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS YEAR 2003 FIRST FULL PRODUCTION YEAR WITHOUT RECYCLE

20 JAN 1998	FIG. No. I–4	DRAWN BY: TM

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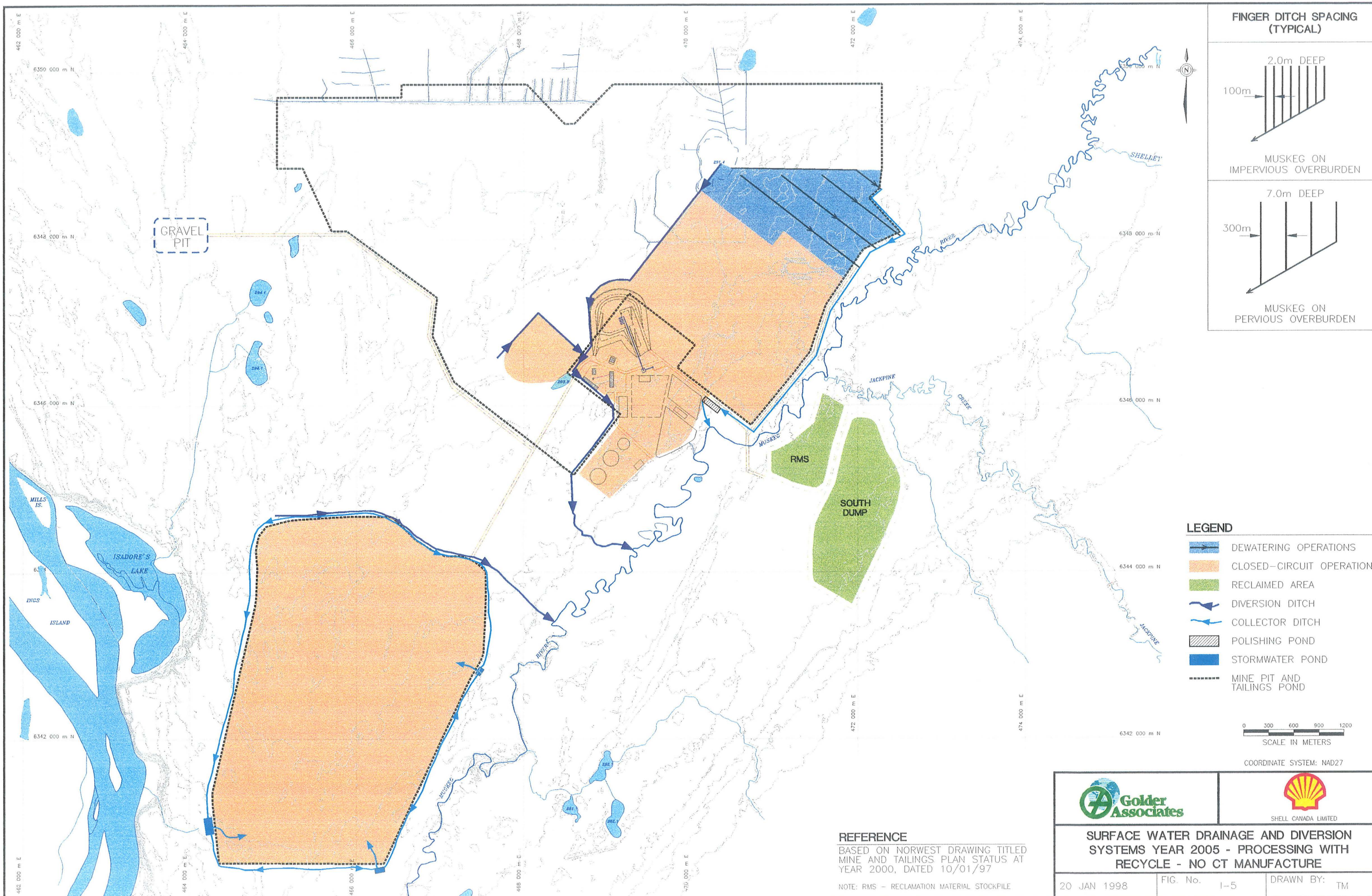
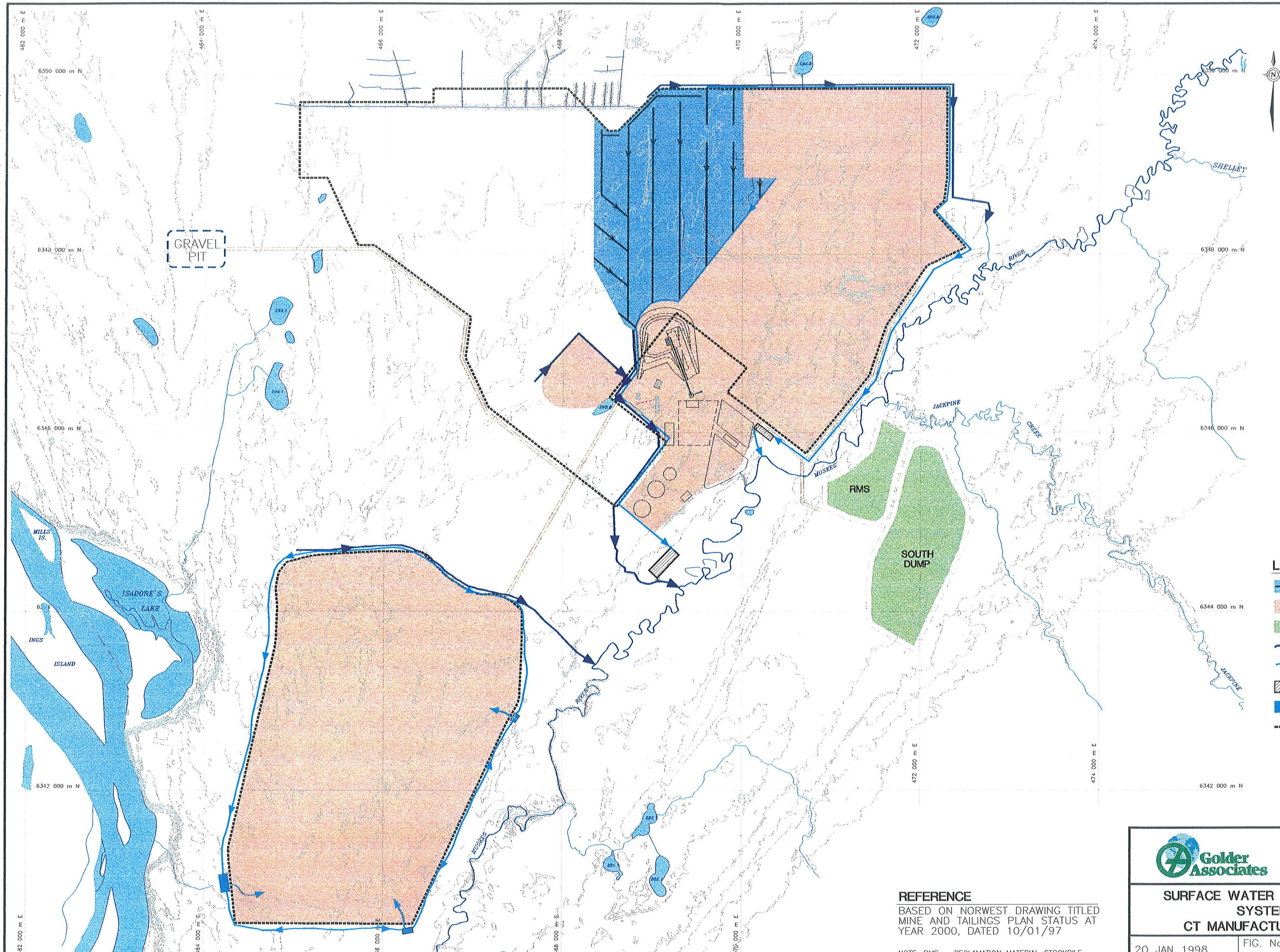
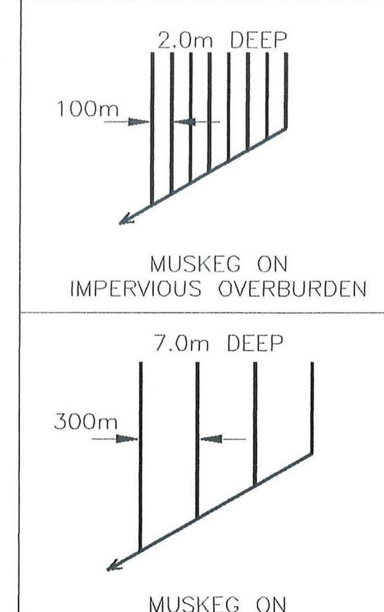




FINGER DITCH SPACING (TYPICAL)



LEGEND

- DEWATERING OPERATIONS
- CLOSED-CIRCUIT OPERATIONS
- RECLAIMED AREA
- DIVERSION DITCH
- COLLECTOR DITCH
- POLISHING POND
- STORMWATER POND
- MINE PIT AND TAILINGS POND

0 300 600 900 1200
SCALE IN METERS

COORDINATE SYSTEM: NAD27

REFERENCE

BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97

NOTE: RMS – RECLAMATION MATERIAL STOCKPILE

Golder Associates

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SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS YEAR 2010 CT MANUFACTURE AT 75% CAPACITY

20 JAN 1998	FIG. No. I-6	DRAWN BY: TM

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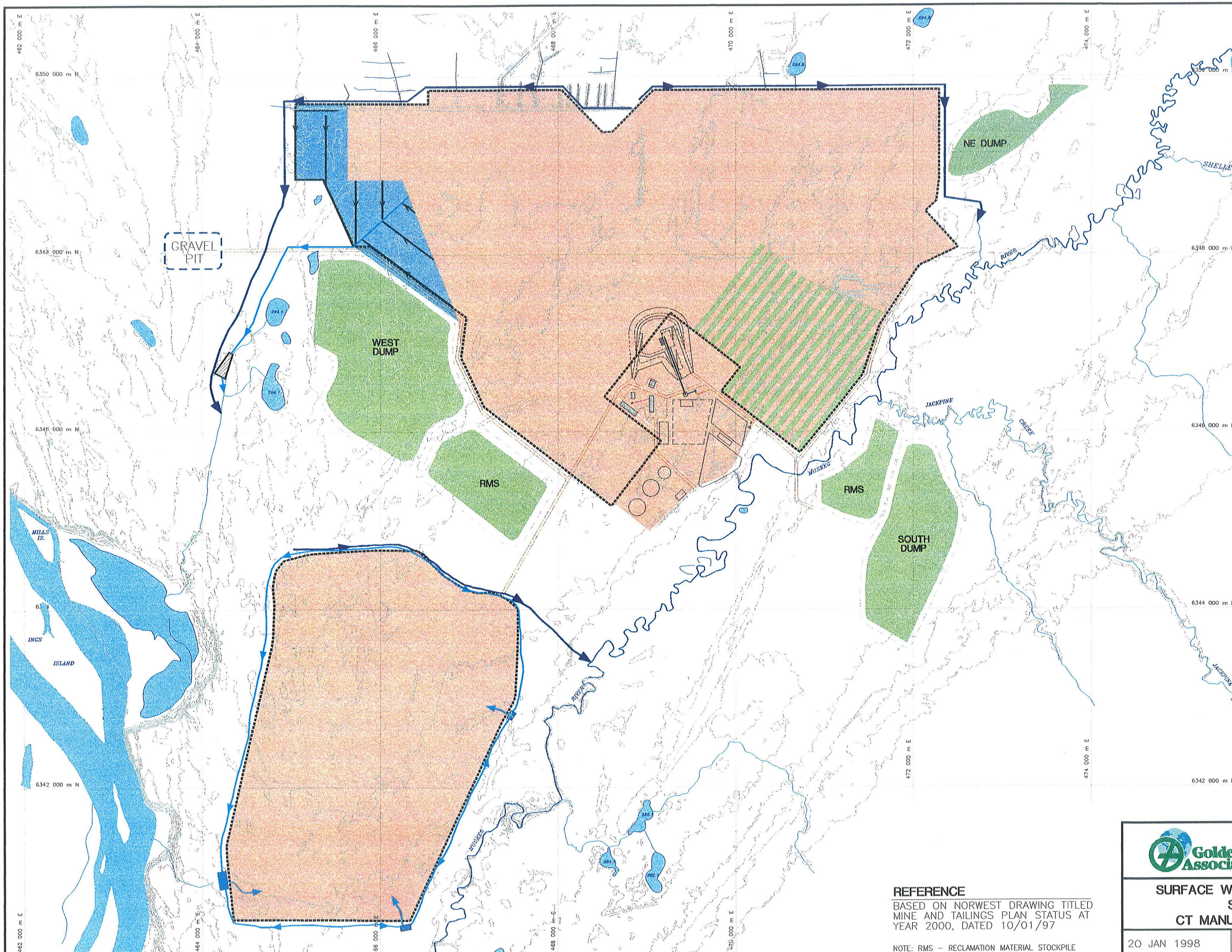

FINGER DITCH SPACING (TYPICAL)

2.0m DEEP
100m
MUSKEG ON IMPERVIOUS OVERBURDEN

7.0m DEEP
300m
MUSKEG ON PERVIOUS OVERBURDEN

LEGEND

- DEWATERING OPERATIONS
- CLOSED–CIRCUIT OPERATIONS
- RECLAIMED AREA
- RECLAIMED AREA STILL IN CLOSED CIRCUIT OF MINE OPERATIONS
- DIVERSION DITCH
- COLLECTOR DITCH
- POLISHING POND
- STORMWATER POND
- MINE PIT AND TAILINGS POND

0 300 600 900 1200
SCALE IN METERS

COORDINATE SYSTEM: NAD27

REFERENCE

BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97

NOTE: RMS – RECLAMATION MATERIAL STOCKPILE

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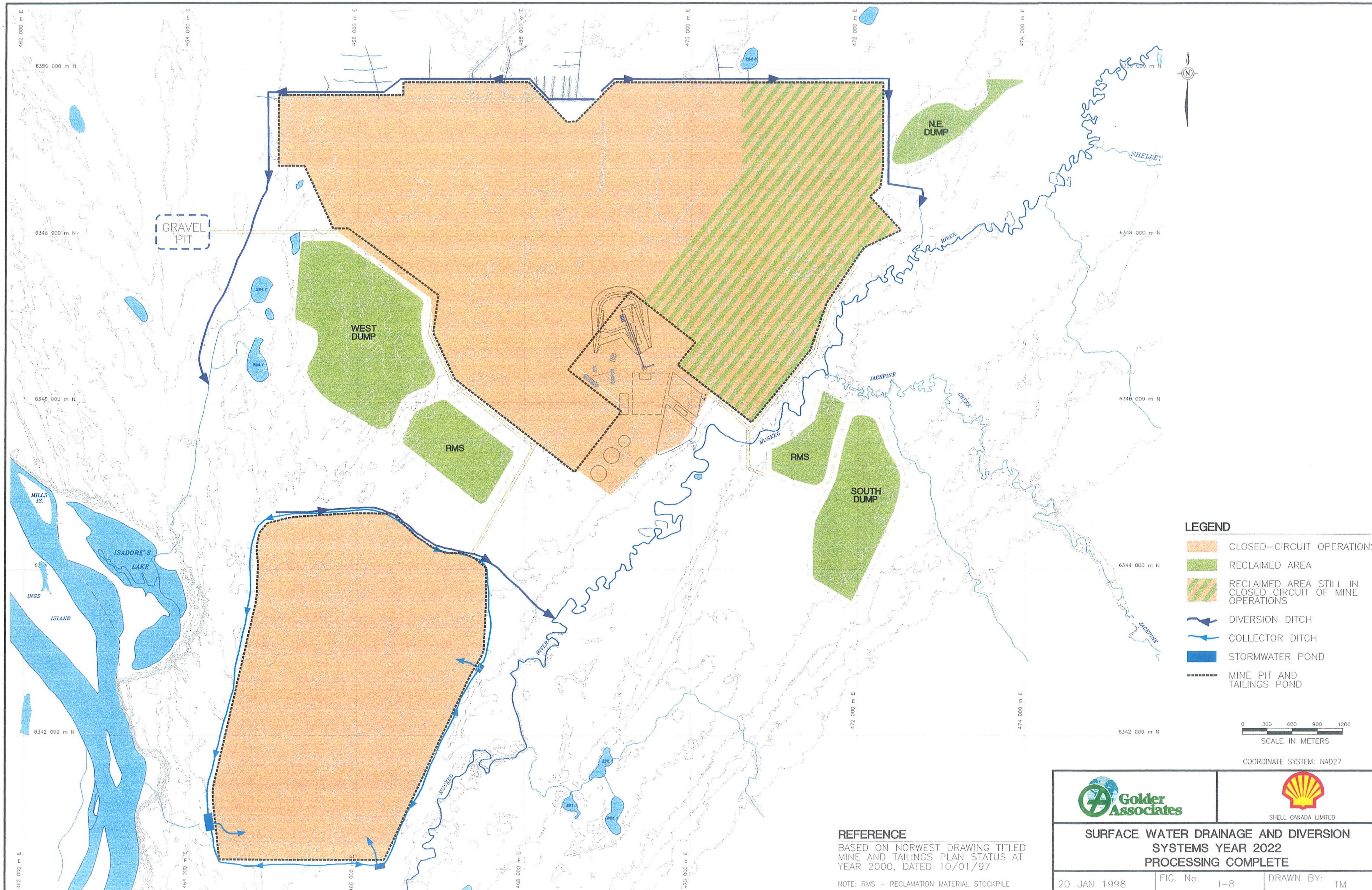
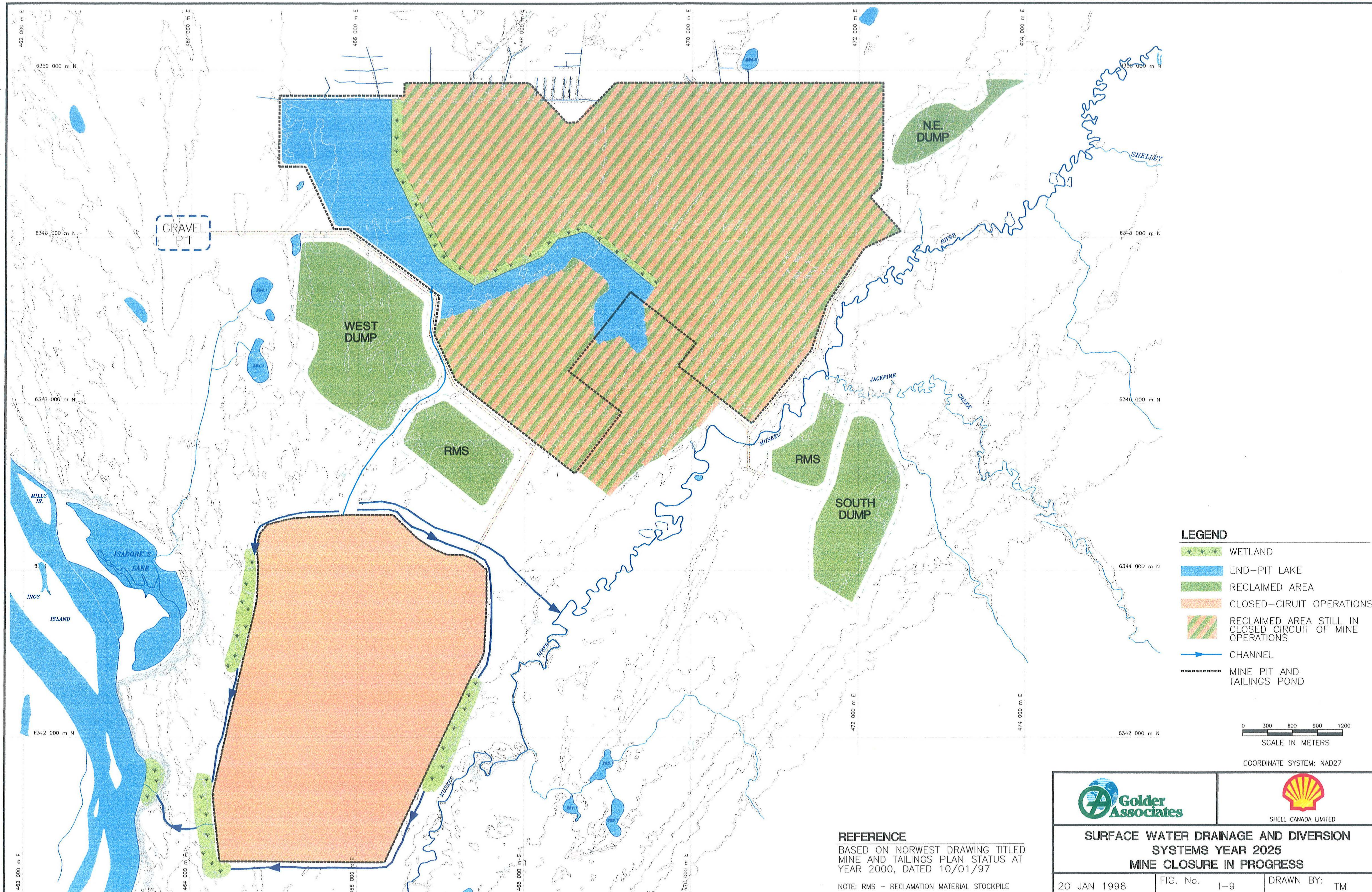
SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS YEAR 2020 CT MANUFACTURE AT 95% CAPACITY

20 JAN 1998	FIG. No. I–7	DRAWN BY: TM



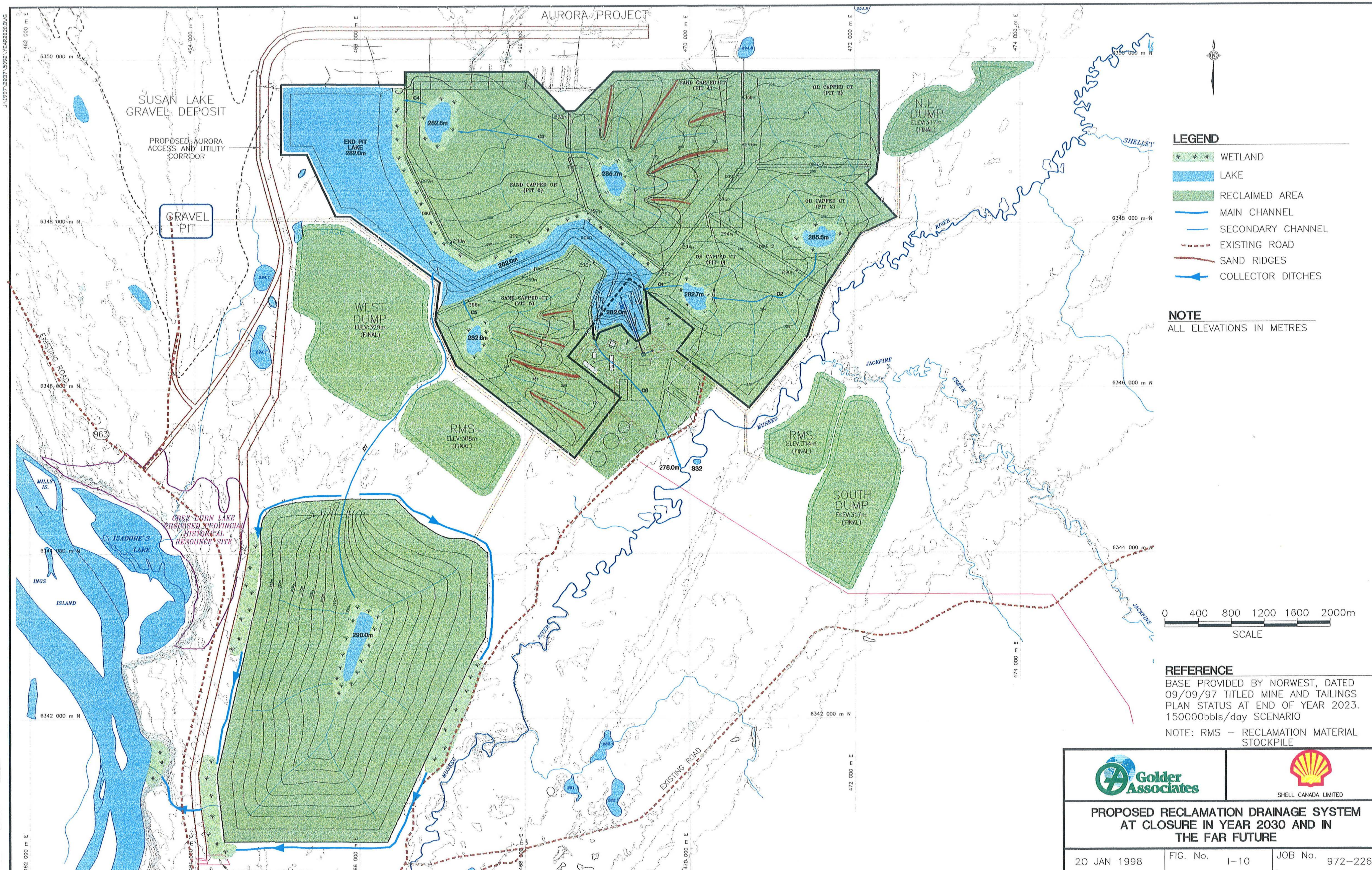
J:\1997\2237\5092\YR2022.DWG
GRAVEL PIT
WEST DUMP
RMS
N.E. DUMP
SHELLEY
RIVER
JACKPINE
CREEK
MUSKEG
RMS
SOUTH DUMP
MILLS IS.
ISADORE'S LAKE
INGS
ISLAND
RIVER
MUSKEG
JACKPINE
LEGEND
CLOSED-CIRCUIT OPERATIONS
RECLAIMED AREA
RECLAIMED AREA STILL IN CLOSED CIRCUIT OF MINE OPERATIONS
DIVERSION DITCH
COLLECTOR DITCH
STORMWATER POND
MINE PIT AND TAILINGS POND
0 300 600 900 1200
SCALE IN METERS
COORDINATE SYSTEM: NAD27
REFERENCE
BASED ON NORWEST DRAWING TITLED MINE AND TAILINGS PLAN STATUS AT YEAR 2000, DATED 10/01/97
NOTE: RMS - RECLAMATION MATERIAL STOCKPILE
Golder Associates
SHELL CANADA LIMITED
SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS YEAR 2022 PROCESSING COMPLETE
20 JAN 1998
FIG. No. I-8
DRAWN BY: TM

J:\1997\2237\5092\YEAR2025.DWG



SURFACE WATER DRAINAGE AND DIVERSION SYSTEMS YEAR 2025
MINE CLOSURE IN PROGRESS

20 JAN 1998	FIG. No. I-9	DRAWN BY: TM



AURORA PROJECT
SUSAN LAKE GRAVEL DEPOSIT
PROPOSED AURORA ACCESS AND UTILITY CORRIDOR
GRAVEL PIT
END PIT LAKE 282.0m
SAND CAPPED OB (PIT 6)
SAND CAPPED CT (PIT 4)
OB CAPPED CT (PIT 3)
OB CAPPED CT (PIT 2)
OB CAPPED CT (PIT 1)
SAND CAPPED CT (PIT 5)
N.E. DUMP ELEV:317m (FINAL)
WEST DUMP ELEV:329m (FINAL)
RMS ELEV:308m (FINAL)
RMS ELEV:314m (FINAL)
SOUTH DUMP ELEV:317m (FINAL)
282.6m
285.7m
285.8m
282.0m
282.7m
290.0m
278.0m
EXISTING ROAD
963
MILLS IS.
ISADORE'S LAKE
INGS ISLAND
CREE BURN LAKE PROPOSED PROVINCIAL HISTORICAL RESOURCE SITE
INDUSTRIAL CAMPSITE
SHELLEY
JACKPINE CREEK
MUSKEG RIVER
LEGEND
WETLAND
LAKE
RECLAIMED AREA
MAIN CHANNEL
SECONDARY CHANNEL
EXISTING ROAD
SAND RIDGES
COLLECTOR DITCHES
NOTE
ALL ELEVATIONS IN METRES
0 400 800 1200 1600 2000m
SCALE
REFERENCE
BASE PROVIDED BY NORWEST, DATED 09/09/97 TITLED MINE AND TAILINGS PLAN STATUS AT END OF YEAR 2023. 150000bbls/day SCENARIO
NOTE: RMS – RECLAMATION MATERIAL STOCKPILE
Golder Associates
SHELL CANADA LIMITED
PROPOSED RECLAMATION DRAINAGE SYSTEM AT CLOSURE IN YEAR 2030 AND IN THE FAR FUTURE
20 JAN 1998
FIG. No. I-10
JOB No. 972-2263

APPENDIX II

ASSUMPTIONS, INPUT DATA AND WATER BALANCE PARAMETERS

LIST OF TABLES

Table II-1
Data Inputs from AEE

	Tailing Pond					Cyclone			In-Pit Disposal					
Period Starting:	Slurry Water Inflow (M m^3)	Water Sand (M m^3)	Water in MFT (M m^3)	Recycle Outflow (M m^3)	MFT to CT Manuf. (M m^3)	Slurry into Cyclone (M m^3)	Cyclone Overflow (M m^3)	Cyclone Underflow (M m^3)	Water Beach (M m^3)	Water TFT (M m^3)	Water CT (M m^3)	Imm. CT Release (M m^3)	Water in Underflow (M m^3)	Water Released From CT In-Pit (M m^3)
Jan-99														
Jan-99														
May-00														
Nov-00														
May-01														
Nov-01														
Jul-02	29.870	9.170	11.100	-9.600										
Jan-03	59.750	18.340	18.710	-22.700										
Jan-04	58.160	17.830	13.870	-26.460										
Jan-05	58.440	17.920	12.240	-28.280										
Jan-06	53.310	13.370	15.350	-24.590	-4.450	18.180	-10.880	-7.300	0.790	0.390	5.550	0.590	4.430	4.440
Jan-07	48.280	9.830	16.040	-22.390	-7.390	30.190	-18.070	-12.120	1.300	0.650	8.840	0.970	7.750	7.740
Jan-08	48.740	9.940	14.970	-23.840	-7.480	30.490	-18.250	-12.240	1.320	0.660	8.320	0.980	8.440	8.430
Jan-09	48.180	10.000	10.930	-27.250	-7.300	30.140	-18.050	-12.090	1.300	0.640	7.600	0.970	8.880	8.880
Jan-10	40.200	5.490	11.950	-22.770	-10.470	43.120	-25.820	-17.300	1.860	0.920	11.000	1.380	12.610	12.610
Jan-11	38.530	3.970	12.240	-22.320	-12.160	49.710	-29.760	-19.950	2.150	1.070	12.530	1.600	14.760	14.770
Jan-12	39.850	4.110	13.330	-22.420	-12.530	51.410	-30.780	-20.630	2.220	1.100	14.980	1.650	13.210	13.210
Jan-13	36.700	2.320	13.810	-20.570	-13.820	56.350	-33.730	-22.620	2.440	1.220	15.470	1.820	15.490	15.510
Jan-14	37.940	2.400	14.290	-21.250	-14.370	58.270	-34.870	-23.400	2.520	1.260	14.980	1.880	17.130	17.150
Jan-15	38.910	2.460	14.920	-21.530	-18.280	59.730	-35.760	-23.970	2.580	1.840	14.690	1.920	21.220	21.220
Jan-16	36.470	2.300	12.620	-21.540	-17.100	55.980	-33.520	-22.460	2.420	1.720	13.000	1.800	20.620	20.620
Jan-17	35.990	2.270	12.650	-21.070	-16.880	55.260	-33.090	-22.170	2.390	1.700	16.640	1.770	16.550	16.550
Jan-18	35.990	2.270	12.850	-20.870	-16.880	55.260	-33.090	-22.170	2.390	1.700	15.500	1.770	17.690	17.690
Jan-19	35.990	2.270	12.940	-20.780	-16.880	55.260	-33.090	-22.170	2.390	1.700	14.390	1.770	18.800	18.800
Jan-20	35.990	2.270	13.050	-20.670	-16.880	55.260	-33.090	-22.170	2.390	1.700	13.320	1.770	19.870	19.870
Jan-21	35.990	2.270	13.070	-20.850	-16.880	55.260	-33.090	-22.170	2.390	1.700	16.450	1.770	16.740	16.740
Jan-22	35.710	2.250	13.120	-20.340	-16.530	54.800	-32.830	-21.970	2.360	1.670	15.130	1.740	17.600	17.590
Jan-23													8.780	8.780
Jan-24													7.530	7.530
Jan-25													5.320	5.320
Jan-26													4.750	4.750
Jan-27													3.040	3.040
Jan-28													2.490	2.490
Jan-29													1.790	1.790
Jan-30													1.250	1.250
Jan-31													1.250	1.250
Jan-32													0.840	0.840
Jan-33													0.840	0.840
Jan-34													0.440	0.440
Jan-35													0.440	0.440
Jan-36													0.270	0.270
Jan-37													0.270	0.270
Jan-38													0.270	0.270
Jan-39													0.270	0.270
Jan-40													0.270	0.270
Jan-41													0.270	0.270
Jan-42													0.270	0.270
Jan-43													0.270	0.270
Jan-44														
Jan-45														

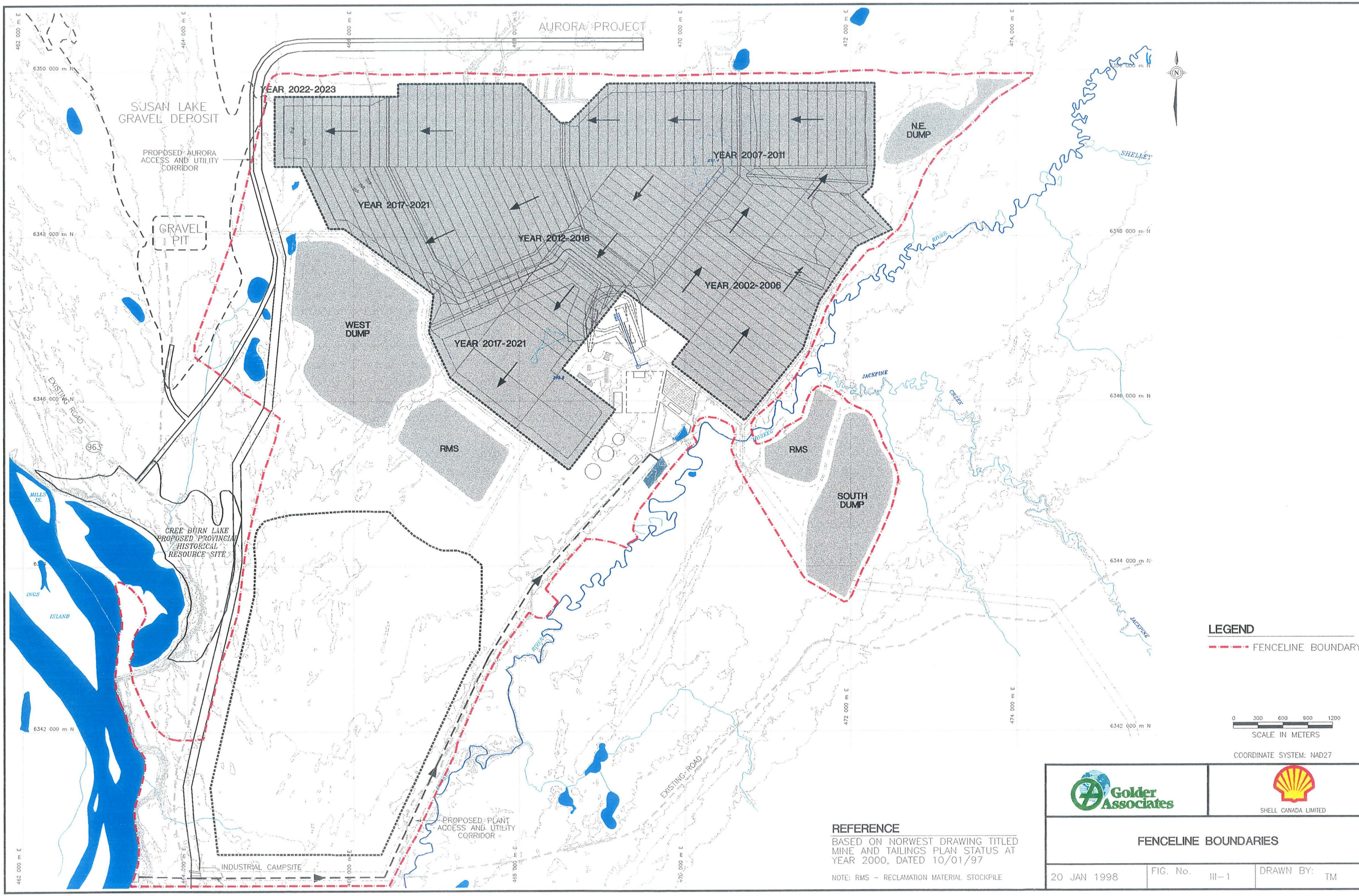
Table II-2
Area and Drainage Inputs for Water Balance

	Areas (km^2)									Drainage (million m^3/y)		
Period Starting:	Additional New Area De-water	Open Pit /Overburden Reclaim	Mine Sump	In-Pit Area CT	Area CT Sumps	End Pit Lake	Plant Area	Tailings Dyke Area	Tailings Pond Area	Muskeg Rate	Overburden Rate	Basal Aquifer Rate
Jan-99	3.100									1.43	0.00	0.00
Jan-99								0.00		1.43	0.00	0.00
May-00	0.892						0.50	0.00		1.61	0.63	0.00
Nov-00							1.60	0.00		1.10	0.63	0.00
May-01	0.892						3.10	9.93	0.50	0.82	0.70	0.00
Nov-01							3.10	9.43	1.00	0.82	0.70	0.00
Jul-02	0.892	0.29	0.60	0.00	0.00		3.10	7.43	3.00	0.82	0.70	2.86
Jan-03	0.892	1.18	0.60	0.00	0.00		3.10	4.53	5.90	0.82	0.70	2.19
Jan-04	0.892	2.08	0.60	0.00	0.00		3.10	4.60	5.83	0.82	0.70	1.90
Jan-05	0.941	2.97	0.60	0.00	0.00		3.10	4.66	5.77	0.84	0.74	1.90
Jan-06	0.941	3.86	0.60	0.00	0.00		3.10	4.73	5.70	0.87	0.75	1.90
Jan-07	0.941	0.42	0.60	3.78	0.60		3.10	4.61	5.82	0.87	0.75	2.05
Jan-08	0.941	0.60	0.60	4.55	0.60		3.10	4.49	5.94	0.87	0.75	1.54
Jan-09	0.941	0.77	0.60	5.31	0.60		3.10	4.37	6.06	0.87	0.75	1.32
Jan-10	1.288	0.95	0.60	6.08	0.60		3.10	4.25	6.18	1.03	0.99	1.32
Jan-11	1.288	1.13	0.60	6.84	0.60		3.10	4.13	6.30	1.19	1.02	1.32
Jan-12	1.288	1.37	0.60	7.88	0.60		3.10	4.18	6.25	1.19	1.02	4.02
Jan-13	1.288	1.62	0.60	8.93	0.60		3.10	4.23	6.20	1.19	1.02	3.14
Jan-14	1.288	1.86	0.60	9.97	0.60		3.10	4.28	6.15	1.19	1.02	2.75
Jan-15	1.048	2.10	0.60	11.02	0.60		3.10	4.33	6.10	1.08	0.84	2.75
Jan-16	0.748	2.35	0.60	11.97	0.69		3.10	4.38	6.05	0.83	0.82	2.75
Jan-17	1.048	2.54	0.60	12.49	1.03		3.10	4.43	6.00	0.83	0.82	2.04
Jan-18	1.048	2.68	0.60	10.83	3.29		3.10	4.48	5.95	0.96	0.82	1.55
Jan-19	1.048	2.88	0.60	10.37	4.60		3.10	4.53	5.90	0.96	0.82	1.34
Jan-20	0.388	3.08	0.60	9.92	5.90		3.10	4.58	5.85	0.66	0.24	1.34
Jan-21		3.28	0.60	10.02	6.65		3.10	4.63	5.80	0.18	0.15	1.34
Jan-22		3.35	0.60	7.27	9.72		3.10	4.73	5.70	0.00	0.00	0.79
Jan-23		3.62		16.99		3.43		4.83	5.60			
Jan-24		3.62		16.99		3.43		4.63	5.80			
Jan-25		3.62		16.99		3.43		4.43	6.00			
Jan-26		3.62		16.99		3.43		4.63	5.80			
Jan-27		3.62		16.99		3.43		5.03	5.40			
Jan-28		3.62		16.99		3.43		5.43	5.00			
Jan-29		3.62		16.99		3.43		6.20	0.10			
Jan-30		3.62		16.99		3.43		6.20	0.10			
Jan-31		3.62		16.99		3.43		6.20	0.10			
Jan-32		3.62		16.99		3.43		6.20	0.10			
Jan-33		3.62		16.99		3.43		6.20	0.10			
Jan-34		3.62		16.99		3.43		6.20	0.10			
Jan-35		3.62		16.99		3.43		6.20	0.10			
Jan-36		3.62		16.99		3.43		6.20	0.10			
Jan-37		3.62		16.99		3.43		6.20	0.10			
Jan-38		3.62		16.99		3.43		6.20	0.10			
Jan-39		3.62		16.99		3.43		6.20	0.10			
Jan-40		3.62		16.99		3.43		6.20	0.10			
Jan-41		3.62		16.99		3.43		6.20	0.10			
Jan-42		3.62		16.99		3.43		6.20	0.10			
Jan-43		3.62		16.99		3.43		6.20	0.10			
Jan-44		3.62		16.99		3.43		6.20	0.10			
Jan-45		3.62		16.99		3.43		6.20	0.10			

APPENDIX III

FENCELINE BOUNDARIES

LIST OF FIGURES



J:\1997\2237\5092\FENCEAPP.DWG
AURORA PROJECT
SUSAN LAKE
GRAVEL DEPOSIT
PROPOSED AURORA
ACCESS AND UTILITY
CORRIDOR
GRAVEL
PIT
YEAR 2022-2023
YEAR 2007-2011
YEAR 2017-2021
YEAR 2012-2016
YEAR 2002-2006
YEAR 2017-2021
N.E.
DUMP
WEST
DUMP
RMS
RMS
SOUTH
DUMP
EXISTING ROAD
963
MILLS IS.
INGS
ISLAND
CREE BURN LAKE
PROPOSED PROVINCIAL
HISTORICAL
RESOURCE SITE
SHELLEY
RIVER
JACKPINE
CREEK
MUSKEG
RIVER
JACKPINE
EXISTING ROAD
PROPOSED PLANT
ACCESS AND UTILITY
CORRIDOR
INDUSTRIAL CAMPSITE
462 000 m E
464 000 m E
466 000 m E
468 000 m E
470 000 m E
472 000 m E
474 000 m E
6350 000 m N
6348 000 m N
6346 000 m N
6344 000 m N
6342 000 m N
LEGEND
FENCELINE BOUNDARY
0 300 600 900 1200
SCALE IN METERS
COORDINATE SYSTEM: NAD27
REFERENCE
BASED ON NORWEST DRAWING TITLED
MINE AND TAILINGS PLAN STATUS AT
YEAR 2000, DATED 10/01/97
NOTE: RMS – RECLAMATION MATERIAL STOCKPILE
Golder Associates
SHELL CANADA LIMITED
FENCELINE BOUNDARIES
20 JAN 1998
FIG. No. III-1
DRAWN BY: TM