High capacity well permit application. 1995

Foth and Van Dyke and Associates, Inc.
Green Bay, Wisconsin: Foth and Van Dyke, 1995

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Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
RHINELANDER, WI 54501-3161

Jerome D. Goodrich, Jr.
PRESIDENT

December 13, 1995

Mr. Charles Fitzgerald
Wisconsin Department of Natural Resources
North Central District
107 Sutcliff Avenue
Rhinelander, WI 54501

Mr. David L. Ballman, Ecologist
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

SUPERSEDED

Dear Mr. Fitzgerald and Mr. Ballman:

Re: Crandon Project - *High Capacity Well Permit Application*

Crandon Mining Company (CMC) is pleased to provide you with the enclosed updates to its *High Capacity Well Permit Application*. The updates have been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. in response to questions and comments from Mr. James Scharch of the Wisconsin Department of Natural Resources. As noted on the attached distribution list, CMC has distributed the enclosed information to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution to their appropriate staff members.

Also attached is a reference list with information indicating where to insert the revised pages in the three ring notebook for the *High Capacity Well Permit Application* previously provided in October, 1995. The list has been prepared to both facilitate insertion of the additional information, and to serve as a log and reference identifying changes made to the document by CMC throughout the permitting process. If subsequent revisions are made, they will be added to the attached list in sequential order and the list will be forwarded with the changes.

If you or your staff have any questions regarding the updates, please contact me at (715) 365-1450.

Sincerely,

Jerome D. Goodrich, Jr.
President
Crandon Mining Company

MLD2\93C049\GBAPP\6670\4000

Telephone: (715) 365-1451

FAX: (715) 365-1457

Crandon Mining Company

7 N. BROWN ST., 3RD FLOOR
RHINELANDER, WI 54501-3161

Jerome D. Goodrich, Jr.
PRESIDENT

October 10, 1995

Mr. Charles Fitzgerald
Wisconsin Department of Natural Resources
North Central District
107 Sutcliff Avenue
Rhinelander, WI 54501

Mr. David L. Ballman
Ecologist
U.S. Army Corps of Engineers
St. Paul District
190 Fifth Street East
St. Paul, MN 55101

Dear Mr. Fitzgerald and Mr. Ballman:

RE: Crandon Project - *High Capacity Well Permit Application*

Crandon Mining Company (CMC) is pleased to submit the attached report titled *High Capacity Well Permit Application* for its Crandon Project. This application has been prepared in accordance with Chapter NR 812, Wis. Admin. Code., and outlines the planned project groundwater withdrawal activities which include mine dewatering, and potable and non-potable water supply well construction and uses. This *High Capacity Well Permit Application* is submitted under Section 144.855(3), Wis. Stats., which requires that groundwater withdrawal be approved under Section 144.025(2)(e), Wis. Stats.

The *High Capacity Well Permit Application* has been prepared on behalf of CMC by Foth & Van Dyke and Associates Inc. As noted on the attached distribution list, CMC has distributed the document to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution of the document to their appropriate staff members.

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Telephone: (715) 365-1451

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AUG 3/69

CMC is requesting that the WDNR review this application as expeditiously as possible such that permitting activities associated with the project can continue in a timely manner. If you or your staff have any questions regarding the report, please contact me at (715) 365-1450.

Sincerely,

Jerome D. Goodrich, Jr.
President
Crandon Mining Company

JG:mld2

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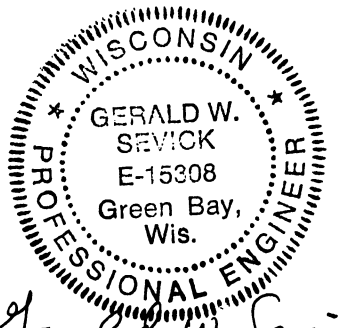

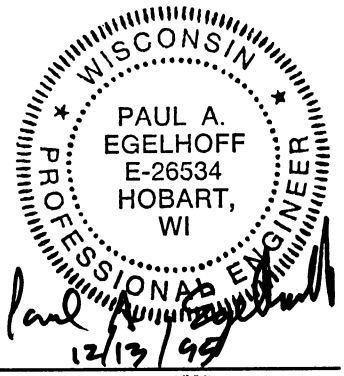

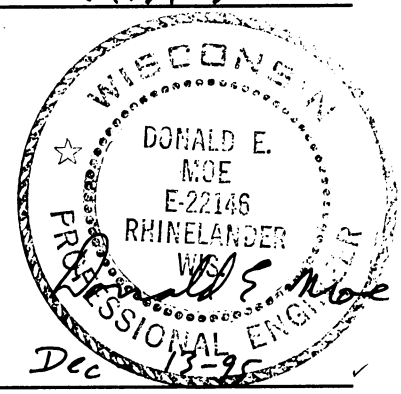

High Capacity Well Permit Application for the Crandon Project

93C049

Prepared for
Crandon Mining Company
7 North Brown Street, 3rd Floor
Rhinelander, Wisconsin 54501-3161

Prepared by
Foth & Van Dyke and Associates Inc.

October 1995
Updated December 1995

2737 S. Ridge Road, P.O. Box 19012, Green Bay, Wisconsin 54307-9012, 414/497-2500, FAX: 414/497-8516

Crandon Mining Company
High Capacity Well Permit Application

Executive Summary

Introduction

As part of the Crandon Project permitting process, Crandon Mining Company (CMC) must secure from the Wisconsin Department of Natural Resources (WDNR) a permit to withdraw groundwater for mine-related activities. The *High Capacity Well Permit Application* describes these activities and the effects they are estimated to have on water resources in the area.

Groundwater Drawdown

The best engineering judgement is that water will enter the mine at about 600 gallons per minute (gpm). Some water will be used in the mine for operations like drilling and dust control. Water will also be pumped to the surface, treated to WDNR water-quality standards, and discharged to the Wisconsin River. CMC will use proven, widely-used grouting methods to minimize groundwater seepage into the mine. However, CMC is not able to quantify the effectiveness of any grouting program.

Groundwater modeling indicates that the mine inflow could range from a low of about 350 gpm to a practical worst case of about 1,150 gpm. Because of mine inflow, groundwater around the mine will be drawn down slowly over several years. This slow process will be monitored closely by measuring a series of approximately 70 monitoring wells. Under the most likely impacts, modelled by the best engineering judgement case, 2,000 feet (0.4 mile) from the orebody, the groundwater will be drawn down by about ten feet. At 9,000 feet (1.7 miles) from the orebody, the drawdown will be about two feet which is the smallest change that can be typically distinguished from natural variation in water levels. The area in which the water table will be drawn down is confined mostly to property owned by CMC.

Effects on Water Wells

Effects of the groundwater withdrawal on private water supplies will be limited to an area within approximately 9,000 feet of the mine. CMC studies show that 12 wells on land not owned by the company may be affected. To assure an ample water supply for these property owners should any of these wells become unusable, CMC will either lower the pump in the existing well, deepen the well and lower the pump, or drill a new well, if it is required. These options will be discussed with the affected property owners. A groundwater monitoring program will be in place to measure changes in water levels long before any impacts on private wells could occur so appropriate actions to protect the well owner can be taken, if needed.

To measure likely effects on area wells, CMC conducted an inventory of public and private water supplies around the mine in the summer of 1994. This work, covering portions of Forest and Langlade counties, added to similar inventories conducted in 1982 and 1984. In all, these inventories gathered information on more than 200 wells within a 336-square-mile area.

Effects on Water Resources

Skunk Lake, a 6-acre lake on the mine property with a maximum depth of five feet, no fish population and no cottages is estimated to be the only lake that will experience a notable lowering of its water level due to mine dewatering. To mitigate the impact, CMC will install a water discharge pipeline to allow pumping of groundwater from a new well on the mine property into the lake when necessary. Of the other four lakes nearest the mine, there will be no effect on Oak Lake and negligible effects — less than one inch — on Little Sand, Duck and Deep Hole lakes. Water level changes on Rice and Rolling Stone lakes will be too small to measure. There will be no change at all in water levels on Lucerne, Metonga, Ground Hemlock, Mole, Crane, Pickerel, St. Johns, Walsh, Kimberly, Clark or any other lakes more than two miles from the mine.

New Well Installations

CMC will drill two new wells for the mine:

- A potable water well about half a mile south of the plant site and west of Little Sand Lake will supply water to mine facilities for drinking, showers and other domestic uses. It will also supply mitigation water for Skunk Lake when required.

- A TMA well just north of the tailings management area will supply water intermittently for work related to construction of the four tailings cells.

Crandon Mining Company
High Capacity Well Permit Application

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Tables

Figures

(Note: Figures for the High Capacity Well Permit Application are located at the end of the text, following page 32.)

Appendices

1 Introduction

Crandon Mining Company (CMC) is proposing to develop an underground zinc-copper mine in Forest County, Wisconsin. Pursuant to Chapter NR 132.05, Wis. Admin. Code, CMC submitted a Notice of Intent to Collect Data and Detailed Scope of Study (NOI/SOS) for the Crandon Project to the Wisconsin Department of Natural Resources (WDNR) on February 15, 1994. As part of further development of this project, numerous federal, state and local environmental, construction, building and safety permits and approvals need to be obtained. This submittal constitutes the High Capacity Well Permit Application (HCWPA) for the groundwater withdrawal activities associated with the Crandon Project.

The HCWPA outlines the planned project groundwater withdrawal activities which include mine dewatering and potable and non-potable water supply well construction and use. This HCWPA has been prepared in accordance with applicable portions of Chapter NR 812, Wis. Admin. Code.

A number of parallel applications have been submitted to the WDNR and U.S. Army Corps of Engineers (USCOE) in support of the Crandon Project permitting process. The major documents and permit applications are listed below:

- Environmental Impact Report (EIR)
- Environmental Impact Report Supplement: Wisconsin River Discharge Pipeline
- Air Pollution Control Permit Application
- Water Regulatory Permit Application pursuant to Chapters 30 and 31, Wis. Stats.
- Water Regulatory Permit under Section 404 of the Federal Clean Water Act
- Notice of Intent for Storm Water Discharges Associated with Construction Activities Under a General WPDES Permit
- Mine Permit Application (MPA)
- Tailings Management Area (TMA) Feasibility Report/Plan of Operations
- Wisconsin Pollutant Discharge Elimination System (WPDES) Permit Application
- Preliminary Engineering Report for Wastewater Treatment Facilities

An attempt has been made during the preparation of the above documents to avoid duplication. Therefore, this permit application refers to information provided in the above documents whenever possible.

The HCWPA has been prepared based on engineering and other environmental studies as they relate to the design, operation, closure and post-operational care and maintenance of the Crandon Project facilities. The material presented in this application is indicative of the type and size of facilities to be constructed and operated as part of the Crandon Project. During final design it is likely that some modification in the engineering and operational details of the facilities and systems will occur. The HCWPA is intended to be self-contained; but, some cross-referencing to the other documents is necessary.

The HCWPA is organized into five sections. The first section is the Introduction. Section 2 contains a general description of the main elements of the Crandon Project. Section 3 contains the detailed information concerning the groundwater withdrawal activities specifically related to the HCWPA for the Crandon Project. Section 4 contains the description of measures CMC will implement to mitigate effects of groundwater withdrawal required for the Crandon Project. Section 5 contains the list of references supporting the HCWPA report.

2 General Project Description

The main elements of the Crandon Project consist of an underground mine; ore concentrating facilities; water treatment facilities; a tailings management area; a water discharge pipeline and ancillary facilities such as an access road, a railroad spur line, and service and support facilities. An extensive description of the project is included in the Mine Permit Application. Following is a brief overview describing the entire project. The overview discusses the location of the mining facilities, the geology of the orebody, the mining process and the major project components which will be developed to operate and reclaim the proposed project in a manner which protects public health, safety, and the environment. The relative location of the project is shown on Figure 2-1.

The anticipated rate of production, project life and projected employment requirements for the project are shown in Table 2-1. As with any industrial operation, the life of the facility could change based on economic conditions.

Table 2-1

Anticipated Production and Operation Data

Daily Ore Production	5,500 tons
Annual Ore Production	2,000,000 tons
Total Ore Production	55,000,000 tons
Total Estimated Project Life	35 years
Preproduction	3 years
Mining	28 years
Reclamation	4 years
Production Schedule	7 days/week
Employment (estimates)	
Construction (Peak)	750
Operations	402-526

Prepared by: PAE
Checked by: JWS

Within this section there are numerous references to the "project area", "mine site", "plant site" and the "tailings management area". These terms have specific meanings as follows.

- Project Area - The project area is defined by the boundaries delineated on Figure 2-2.

- Mine Site - The mine site is defined by the limits of disturbance of project facilities within the project area.

- Plant Site - The plant site is generally defined as the area within the mine site that includes all mining, processing, concentrating, water treatment, administrative, and storage facilities; portions of the railroad spur in the vicinity of the plant site; portions of the access road in the vicinity of the plant site; ventilation raises; and the project's water supply well and its accompanying pipeline corridor. The plant site also includes all surface water runoff and storage basins constructed in its vicinity.

- Tailings Management Area (TMA) - The "TMA" is defined as the area within the "mine site" that includes the project's four tailings cells and berms, the reclaim pond, the tailings and reclaim water pipeline and access road corridors, and contiguous borrow and storage areas. The TMA also includes all surface water drainage facilities constructed in its vicinity.

Two additional areas located outside of the project area include the narrow corridor from the intersection of the site access road and State Trunk Highway (STH) 55 to the Wisconsin River in which the project's treated water discharge line is to be located, and the project's wetland mitigation site located off-site in Shawano and Oconto Counties. Design information for the discharge pipeline to the Wisconsin River is included as part of the water treatment system engineering report prepared pursuant to Wisconsin Administrative Codes. Design information relative to the wetland mitigation site is included as part of the Federal Clean Water Act Section 404 permit application. For completeness the description of the environmental aspects associated with these areas are included in the project's EIR.

The boundaries of the project area, plant site and TMA are shown on Figure 2-2. The plant site and the TMA are approximately 128 acres and 355 acres in size, respectively. The total area of disturbance, including the access road and railroad spur, is approximately 550 acres.

2.1 Site Location

The Crandon orebody is located in Forest County, Wisconsin. The civil land survey location is Section 25, Township 35 North, Range 12 East, Town of Nashville, and Section 30, Township 35 North, Range 13 East, Town of Lincoln. The project area is located five miles south of the City of Crandon and two miles east of STH 55 and the Mole Lake Indian Reservation. The plant site is approximately one-quarter mile north of Little Sand Lake and one mile south of Swamp Creek. The primary mine surface facilities, e.g., plant site, will be located north of the orebody. The proposed plant site layout is shown in Figure 2-3. Access to the plant site will be along a new access road from STH 55 northwest of the site. A railroad spur line serving the site will be connected northeasterly to the existing Wisconsin Central Limited Railroad. The project's TMA will be located approximately one mile southeast of the plant site.

The project area shown in Figure 2-2 includes those portions of property which CMC has purchased, leased, optioned for purchase or obtained by easements for use in the development of the plant site, TMA, access roads, railroad spur line and buffer areas.

2.2 Geology

The Crandon deposit is composed of two distinct mineralization types, zinc ore and copper ore. The minerals were deposited during the Precambrian era, about 900 to 2,500 million years ago. The deposit was formed at and just below the ocean floor by mineral bearing fluids of volcanic

origin. Some of the material deposited by this volcanic system was sulfide minerals which accumulated in low spots on the ocean floor. Continued accumulation of other volcanic materials and sediments occurred which buried the sulfide deposit. Deep burial, 33,000 to 50,000 feet, resulted in lithification and metamorphism which hardened and solidified both the host rock and the sulfide deposit over time. Later, a mountain building phase occurred in the region, tilting the volcanic layers and the deposit to a near vertical position. Thereafter, the deposit may have been covered by younger sediments, however weathering and erosion have removed these later rocks. The more recent geological process which has affected the deposit is related to Pleistocene glaciation which left the bedrock buried under unconsolidated glacial overburden deposits.

The Crandon orebody is long and tabular with an approximate width of 100 feet, north-south, and a strike length of 4,900 feet, east-west. Based on the results of drilling, the orebody extends to an approximate depth of 2,200 feet. The interpreted geologic stratigraphy and orebody configuration are shown on Figures 2-4 and 2-5 respectively.

The bedrock in the hanging wall and in the footwall of the orebody consists of a series of fragmental volcanic rocks, fine tuffs (solidified volcanic ash), debris flow (ocean floor and volcanic-derived sediments), breccia (blocky, angular particles), lapilli tuffs (gravel sized volcanic material) and flows. Overlying the bedrock is a sequence of unconsolidated glacial sands, clays, and gravels. The rock in contact with the unconsolidated glacial overburden is weathered to varying degrees. The amount of weathering ranges from simple staining to extreme weathering near the surface which reduced the rock to a clay-like material called massive saprolite. The glacial overburden consists of interbedded and co-mingled glacial till, which is material deposited directly by the glacier, and glacial outwash deposited by streams emanating from the glacier. These glacial deposits are found in various thicknesses in the area ranging from 75 feet to over 250 feet thick.

2.3 Key Project Elements

2.3.1 Mine Development

Access to the mine will be through a main production/service shaft located north of the orebody. The first of two ventilation shafts will be located east of this main production shaft. Underground lateral development drifts will access the orebody from the main shaft at 300-foot vertical intervals. These level development drifts are designed to provide access to the orebody. The lateral extent of a mine level at a given point in time will depend upon the need for access to mining blocks, ore passes, and ventilation raises. A schematic longitudinal section showing a typical main level plan is shown on Figure 2-6.

An underground ramp will also connect mine levels to allow for movement of mobile equipment, supplies, and personnel throughout the mine. This centrally-located ramp is also shown schematically on Figure 2-6.

Mine development will be divided into the following phases:

1) Site preparation and the sinking of the main production shaft and the east ventilation shaft. This phase is expected to take 18 months to complete.

2) The development of the underground ore handling and crushing system, the development of the dewatering system, lateral development into the ore horizons and development of the initial mining blocks (stopes). An internal mobile equipment access ramp will connect the main production ore levels. This phase of mine development is also expected to take 18 months to complete.

As shown on Figure 2-6, mine development and production will begin in areas chosen to avoid weathered bedrock which are expected to be the primary conduits for water inflow into the mine workings.

2.3.1.1 Phase I Development

Phase I development primarily includes simultaneous construction of two vertical shafts in the hanging wall rocks. Each shaft will be concrete lined through the overburden and the weathered subcrop rock. Collar construction through the glacial overburden will include stabilization and hydraulic control by ground freezing or other suitable techniques, followed by the excavation and concrete lining of the shaft into bedrock. If required, inert grout will be pumped under pressure through holes in the collar into the rock and glacial formations to provide a watertight seal. When the collar section of the main shaft and east ventilation shaft are completed, a headframe structure will be erected over each shaft. Conventional shaft sinking by drilling and blasting techniques will then commence at the main shaft and the east shaft concurrently.

During shaft development, it is estimated that the drainage water from both shaft sinkings will be controlled to less than 10 gallons per minute (gpm) by grouting. All shaft water will be pumped to the surface water storage ponds.

2.3.1.2 Phase II Development

Because the east shaft is smaller than the main shaft, it will be completed sooner. Upon its completion, horizontal level development will consist of driving a horizontal opening in the hanging wall rock to connect the east shaft to the main shaft (Figure 2-6). After the two shafts are connected, level development can commence to access the orebody.

The underground ore handling facilities will be constructed near the main production shaft during this period. These facilities will consist of: (a) coarse ore and waste rock storage bins, (b) crusher facilities, (c) ore handling systems, and (d) a loadout facility.

2.3.2 Mine Operations

Level development from the main production shaft to the stopping areas will be driven at 300-foot vertical intervals. The primary mining method will be blasthole open stoping with delayed backfill. However, other mechanized variations, such as sublevel mining or cut-and-fill stoping methods may also be used. Stopes (Figure 2-7) will average approximately 300 feet high by 75 feet long, and will vary with the width of the orebody. Ore will be drilled in a stoping block, then blasted and removed. Top hammer or down-the-hole drills will be used to drill approximately 4- to 6-inch diameter blastholes on approximately 12-foot by 12-foot center spacing for production stope blasting. Broken ore will be removed from the drawpoints at the bottom of each stope using mechanized mining equipment which will then transfer the ore to the

crushing level below by means of ore pass raises. Primary crushed ore, at a top size of eight inches, will be conveyed to a skip loading pocket and hoisted to the surface.

A typical stope will contain approximately 250,000 tons of ore. At a 2,000,000 ton annual production rate, approximately eight stopes will be mined out each year, which exposes less than 5 percent of the footwall and hanging wall area of the orebody at any one time. Exact production parameters will be based on the grade of the ore in the mined stope; the mechanical characteristics of the rock in the stoping block; and the potential for inflow of water.

A permanent bridge, or crown pillar, of bedrock directly beneath the glacial overburden will be purposely excluded from mining activity. This bedrock barrier, averaging approximately 100 feet thick, along with the routine backfilling of mined-out stopes, will maintain surface stability and prevent subsidence.

In the uppermost mine levels where the ore and host rock may have been moderately weakened by superficial weathering, mechanized cut-and-fill mining may be employed. This method is commonly used by the industry and involves removal of horizontal lifts of ore of variable thicknesses. The void created by each horizontal mining pass is backfilled prior to mining the next upper lift. Less than 10 percent of the orebody may require use of this mining method.

The planned mining methods provide for backfilling all stopes following ore extraction. These practices, combined with the fact that 5 to 10 percent of the potentially minable ore will be left in place as pillars throughout the mine, will provide perpetual stability of the mine area bedrock and glacial overburden. Backfilling will also result in the reduction of pathways for water migration as mining progresses.

Mine backfilling will begin with the start of milling operations and after the first stope is depleted. The backfill will consist of mill tailings 10 to 15 micron or greater in size, supplemented with coarse waste rock retained underground. Uncemented tailings backfill will have a hydraulic conductivity on the order of 0.028 feet per day. The hydraulic conductivity of cemented tailings backfill will be lower. Backfill slurry containing approximately 60 to 70 percent solids will be pumped underground through boreholes fitted with distribution pipes. The backfilling operations will normally be conducted to coincide with the mining schedule.

Waste rock material from mine development will be used in the stope backfilling process and will be placed before or during the placement of hydraulic tailings fill. The hydraulically-placed fill will flow into and fill the voids between the rock fragments.

Cement will be added to the backfill when needed to provide stability so that the column of fill will stand unsupported and enable complete removal of the ore in the adjacent stope. Approximately one-third to one-half of the total backfill placed in the mine will contain cement.

2.3.3 Mine Dewatering and Groundwater Inflow Control

Groundwater inflow will vary during the different stages of mine construction and operation. The proposed mining plan for the Crandon Project avoids entry into weathered zones during the initial operations, therefore deferring maximum and steady state inflow rates. During the initial operations, groundwater inflow is expected to be minimal and localized, occurring through isolated bedrock fractures that have limited capacity to move water. During this period,

exploration holes will be advanced into the weathered bedrock areas to dewater them. The water removed in this fashion will primarily be stored water which will be withdrawn at rates that can be effectively managed at the project's water treatment plant. A more detailed description of this process follows.

As mine development progresses upward from the original mining areas (Figure 2-6), diamond drilling techniques will be used to identify active underground water courses prior to advancing the mine face. Diamond drill holes will be used throughout the mine to drain stored water. Flows encountered on the uppermost active mine level will be captured by interceptor drill holes and contained to avoid contamination by mining operations on levels below and to reduce pumping head. A conceptual cross-section of the groundwater interceptor system showing the collection methodology is presented in Figure 2-8. Standard rock grouting techniques, typically using neat cement, may also be used for local inflow control during the early mine years to limit total mine pumpage.

Typically, groundwater interception holes will form conical fans in the weathered rock above the development openings, thus increasing the radius of the drains. As is common practice in other mines, the drill hole collars will be fitted with valves to allow controlled water removal.

Groundwater collected from exploration drilling or other drill holes placed specifically for inflow interception will be routed directly to a clean water sump and pump station near the main shaft in the upper mine level. The collected groundwater will typically be pumped to the water treatment plant on the surface. However, a portion of the water may be retained underground for distribution as mine utility water.

Groundwater seepage that is not captured by the interceptor system will infiltrate the mine workings and ultimately be recovered in the main sumps along with the mine potable, utility and backfill drainage water. Normal mine drainage collection will begin on each mine level where groundwater seepage, utility water and backfill drainage will be ditched to small local sumps excavated in the drift wall. Decant water from the local mine level sumps will be piped or drained through boreholes or ditched to the main mine sumps located adjacent to the production shaft at the lowest level.

The main mine sumps and pump station will generally be arranged as indicated on Figure 2-9. Sumps will consist of downgrade excavations in the wall rock adjacent to the pump station. These will function as pumping reservoirs with an outlet end bulkhead containing the pump suction pipes.

2.3.4 Ore Processing

Ore mined from the Crandon deposit will be physically concentrated at the plant site by adding water to the crushed ore and grinding it to the size of fine sand particles. After grinding, the ore slurry will be pumped to a series of flotation circuits where reagents are added for separating metallic minerals from the ground-up ore. During this process, minerals will be selectively "floated" to the top of the flotation cells and removed. The remaining material, which is called tailings, will be either used as backfill in the mine or hydraulically transported to the TMA. Different flotation circuits require different reagents to concentrate specific individual minerals. A schematic of the ore processing circuits is shown on Figure 2-10. Separate concentrates of

zinc, copper and lead minerals will be recovered by the flotation process. The concentrate from these processes will be thickened and filtered to an 8 to 10 percent moisture content.

The tailings will range in size from sand to very fine particles. The coarser tailings from the mineral separation circuits will be used to backfill the mined-out stopes. The finer fraction will be sent to the TMA.

In the TMA, the tailings will settle to the bottom of the lined basin. Excess water will then be pumped from the TMA basin to a reclaim pond for reuse in the ore processing facility. The ore concentration process, TMA, and reclaim pond are designed to operate as a closed circuit. The concentration process normally requires the continuous addition of "makeup" water. Water in this circuit will not require treatment because a discharge will not normally take place. The water treatment system will be designed to treat tailings pond waters for discharge, if necessary.

2.4 Infrastructure

Infrastructure features to support the mine and milling operations include a water treatment plant, ore and waste rock storage facilities, mining waste management facilities, access road, railroad spur line, electric power transmission lines, a natural gas pipeline, a treated water discharge pipeline, and ancillary buildings and storage facilities. A discussion of each follows.

2.4.1 Water Treatment

A water treatment plant will be constructed as part of the project facilities. It will treat mine water and, if needed, process water prior to discharge. Intercepted groundwater is expected to be representative of natural groundwater quality. If the monitoring of this groundwater indicates that the water quality is not suitable for direct discharge, it will be routed through the water treatment plant. Groundwater that bypasses the interceptor system and comes in contact with mining activities will be commingled with other mine drainage water, such as the water used to cool the drill bits while drilling the blast holes. All of these "contact waters" will be routed through the water treatment plant.

The water treatment plant will include a lime and sulfide precipitation system with filtration and pH adjustment. Treatment solids from this facility will be placed along with the ore processing tailings in the TMA. Mine water will be treated to meet WDNR Water Quality Standards before being discharged to the Wisconsin River via a discharge pipeline installed primarily along the U.S. Route (USR) 8 corridor (Figure 2-11).

The treatment system is designed with two holding ponds to retain the treated water so it can be sampled prior to discharge. This will ensure all water meets discharge standards, prior to discharge.

Sanitary water will also be generated at the facility. Sanitary water will be handled separately through a package sanitary water treatment plant. The treated effluent from this plant will be pumped to the TMA.

2.4.2 Mining Waste Management

Crandon Project mining wastes will include waste rock, tailings, refuse, water treatment plant solids, and laboratory wastes.

Over 50 percent of the waste rock generated by the project will be left in the mine as backfill for mined-out stopes. Limited quantities of waste rock will be brought to the surface during preproduction and managed as discussed in Section 2.4.3 below. As discussed in Section 2.4.4 below, approximately 50 percent of the tailings generated by the project will be returned to the mine as backfill, with the remaining 50 percent placed in the TMA.

During the mining operations on-site laboratories will be used to conduct metallurgical testing for mining grade control and for production quality assurance testing related to milling operations. Wastes generated from the performance of these tests will be placed in the TMA. Approximately 900 cubic yards of general refuse such as office wastes will be generated at the facility each year during the 35 years of construction, operation and reclamation. The reclaimable portion of this waste will be recycled in accordance with state law. The remaining waste materials will be disposed of by a contractor in an approved off-site landfill.

Solids will be generated from the treatment of project generated waters. These solids will be placed in the TMA with the tailings.

2.4.3 Preproduction Ore/Waste Rock Storage Areas

Two storage areas will be located to the north of the main production shaft to store ore and waste rock hoisted to the surface during pre-production mine development. Prior to the commencement of underground crushing and the start of mill operations, approximately 1,050,000 tons of uncrushed ore and waste rock of a maximum size of 24 inches will be placed on the two separate areas. One storage facility which will be lined will be used to store approximately 350,000 tons of ore and about 100,000 tons of Type II waste rock. The remaining 600,000 tons of Type I waste rock will be deposited on an unlined area located east of the lined storage area. Type I waste rock is material that has a very low potential to leach, while Type II waste rock has a higher leaching potential. The lined area is designated as the preproduction ore storage area on Figure 2-3. The unlined area is referred to as the construction material storage area on the same figure. Both storage areas have been designed to accommodate the maximum potential amount of waste rock and ore hoisted from underground during the preproduction period and will occupy a total area of approximately 18 acres.

For the preproduction ore storage area a central ridge will divide the facility on its north-south axis. Each side of the lined pad will slope away from the center. The pad will be bounded by berms with runoff collection ditches which will route water to a lined water storage basin. The base of the pre-production ore storage area will consist of a compacted layer of existing soil overlain by a geomembrane liner. A till cushion will be placed over the geomembrane. Water from this area will be drained to a water storage basin. The location of the basin is sized to hold the volume of water from a 25-year, 24-hour storm event. Water from this basin will be either pumped to the TMA for use in ore processing or to the project's water treatment plant.

The base of the construction material storage area will consist of a compacted layer of existing on-site soil. The base will be sloped to drain toward another of the site's surface water runoff

basins. Water from this runoff basin will be discharged to natural site drainage ways. Following commencement of mill operations, the ore stored in the preproduction storage area will be processed. Type II waste rock stored in this area will be hauled by truck to the TMA for disposal or for use as riprap for TMA internal sidewalls. Type I waste rock will be used as construction material.

2.4.4 Tailings Management Area

All tailings produced by ore processing that are not used for mine backfill, hoisted Type II waste rock, water treatment plant solids and the small amount of laboratory wastes will be placed in the TMA. The TMA has been designed to provide long-term, environmentally-safe containment. Tailings and treatment plant solids will be pumped to the TMA through a high density polyethylene (HDPE) pipeline. Waste rock will be transported to the TMA by truck.

As shown on Figures 2-12 and 2-13, the TMA will consist of four cells, each of which will be lined and include a leachate collection system. The four cells, referred to as TMA 1 through TMA 4 will each be constructed and operated in two stages. TMA 1 and TMA 2 are designed to contain the tailings from processing the zinc ore. TMA 3 and TMA 4 will be used for the copper ore tailings. The approximate capacities and site lives for each cell are shown in Table 2-2.

Table 2-2

Approximate Tailings Management Area Capacity

TMA Cell	Capacity (in millions of cubic yards)	Approximate Site Life (years)
TMA 1	4.0	6
TMA 2	7.8	10
TMA 3	3.9	6
TMA 4	4.8	6
Total	20.5	28

Prepared by: PAE
Checked by: JWS

TMA cell construction and operation will first involve constructing and filling Stage 1 of TMA 1. As the tailings in Stage 1 approach the design elevation, Stage 2 of TMA 1 will be built. When approximately one to two years of capacity remain in TMA 1, construction of Stage 1 for TMA 2 will begin. When TMA 1 is full, tailings placement in TMA 2 will start. After consolidation, reclamation of TMA 1 will begin, while filling in TMA 2 progresses. The same process will continue for TMA 3 and TMA 4.

The tailings slurry will be transported from the concentrator building to the TMA through an approximate 16-inch inside diameter HDPE aboveground pipeline. The location of the pipeline is shown on Figure 2-2. The pipeline will lie above ground in a lined ditch. A 22-foot wide

access road will be located next to the pipeline for service and maintenance. Pumps used for pumping the tailings slurry in the pipe will be located in the concentrator building. The pipeline ditch will be sloped to lined sumps located at the plant site and approximately midway between the plant site and the TMA to collect tailings and water in the event of leakage or to provide storage if the pipe must be drained.

The tailings slurry will be deposited in the active TMA cell using spigots. The spigot discharge point(s) will be regularly moved around the inner perimeter of the active cell to facilitate even distribution of tailings and to keep the tailings saturated. The excess water that drains from the slurry after the tailings have settled will flow to an area in the center of the cell and will be pumped to the reclaim pond. Water in the reclaim pond will be retained for a short time and then pumped to the mill for reuse in the process circuit. The tailings operating system is designed to maximize tailings density.

The TMA cells have been designed to meet the standards contained in applicable state statues and administrative codes which are written to protect the public health and welfare. Key TMA design features include:

- An average 43-foot separation from the base of the TMA to groundwater.
- A minimum 1,250-foot separation from the nearest lake or stream.
- A composite liner consisting of a low-permeability soil member and a geomembrane liner.
- A leachate collection system over the bottom of each cell and partially up the interior sidewalls of each cell.
- A reclaimed final cover consisting of the following components from top to bottom.
    - topsoil
    - rooting layer
    - drainage layer
    - geomembrane liner
    - low permeability soil liner
    - grading layer
- Surface water control structures designed to accommodate a 100-year, 24-hour storm event.

2.4.5 Access Roads

A site access road will be constructed from STH 55 to the plant site. A second access road will be constructed from the plant site to the TMA. The site access road will be approximately three miles long and consist of bituminous concrete with gravel shoulders. The treated water discharge line will be buried in the right-of-way of the site access road. The TMA access road will be approximately one mile long and will be gravel-surfaced. Pipelines for tailings disposal and reclaim water will be sited adjacent to the TMA access road in a lined ditch.

2.4.6 Railroad Spur

A 2.7-mile railroad spur line will be constructed from the plant site to the Wisconsin Central Limited Railroad located to the northeast. The spur line will consist of a single track along most of its corridor. A side track will be located near the point where the spur line connects with the main railroad line. The sidetrack will be used for switching and railcar staging. The spur line will be used to bring cement, lime and other materials to the plant, and to ship concentrates to market. Concentrate will be shipped in enclosed cars or containers.

2.4.7 Utilities

Electrical service to the project site will be provided by Wisconsin Public Service Corporation (WPSC) by an electric transmission line constructed between an existing substation near Monico, Wisconsin, and a new substation to be located at the plant site. The substation near Monico will be upgraded by WPSC as part of the extension of electrical power for the project.

The WPSC area distribution system, which will likely be located near the south end of Lake Metonga, will supply natural gas for the project via a pipeline installed to the plant site. The pipeline route will follow existing county roads, cross Swamp Creek north of the plant site, and then follow the main plant access road into the site.

2.4.8 Other Facilities

In addition to the project elements discussed above other site facilities as listed below will be constructed and used as part of the project:

- Administrative offices
- Changehouse facilities
- Explosive storage areas
- Gate house
- Core logging and storage
- Covered storage area
- Truck weigh scale
- Fencing
- On-site roads
- Area lighting
- Surface maintenance shops
- Potable water supply and distribution system
- Fire protection systems
- Lubricant storage
- Bulk fuel storage
- Lay-down areas
- Railroad weigh scale
- Mobile equipment fuel station
- Parking areas
- Material storage areas

2.4.9 Surface Water Controls

Precipitation falling within the limits of the plant site will be collected and directed to one of a number of water storage basins. Contact runoff will be directed to the water treatment plant or to the TMA. Non-contact runoff will be directed to existing natural drainage features after passing through runoff basins. Precipitation falling within the TMA will co-mingle with process water and become part of the water used in the mill circuit. Some of the surface water drainage originating from outside the active mining area will be intercepted by a series of drainage swales and directed to existing natural drainage features.

2.4.10 Wetland Mitigation

Although mine facilities have been designed to minimize impacts on wetlands, as part of project construction activities, approximately 29.5 acres of wetlands will be either excavated or filled. To compensate, CMC will develop replacement wetlands on a site located in Shawano and Oconto Counties. The selected site is in an area that was originally wetlands, but was converted to cropland. The establishment of the compensation site involves reconverting it from cropland back to wetlands.

2.4.11 Mine Reclamation

Topsoil will be salvaged and stored from all disturbed areas for use in reclamation activities. Reclamation of the mining site will occur on an ongoing basis during construction and operation, and as the final phase of the project. After mining, the area will be used for forestry and as open green space. During construction, disturbed soil areas will be revegetated on a continual basis such that wind and water erosion potential is significantly reduced. These areas will either be temporarily reclaimed or finally reclaimed depending upon their location relative to future construction activities.

Final reclamation of the plant site will begin after completion of mining. All open boreholes will be sealed in compliance with applicable regulations. Salvageable equipment from the mine will be brought to surface. Any equipment left underground will have potentially harmful fluids removed. The shafts to the mine will be sealed with reinforced concrete plugs. Surface facilities may be converted to other uses if possible. If other uses are not feasible, those facilities will be removed. The site area will be regraded and revegetated. Settling basins and ponds will be drained and the area reclaimed. Containment structures will be removed. Disturbed areas will be regraded and revegetated. The TMA will be reclaimed in phases during its lifetime. Final closure of the last cell of the TMA will occur late in the sequence of project reclamation.

The water treatment plant and associated pipelines will be removed after they are no longer required. Salvageable equipment will be transported off-site. Scrap and treatment solids will be placed in the TMA prior to closure of the final cell. Buried segments of pipelines will be purged and left in place. Above-grade pipelines will be removed. The water treatment plant area and pipeline routes will be graded and revegetated.

On-site roads, the plant site access road and the railroad spur line will be among the last items to be reclaimed. Reclamation of these features would be dependent upon the final site use. If no future use is anticipated, the construction materials will be removed. Bituminous pavement will be salvaged for use elsewhere, if possible, or placed in the TMA. Rail will be salvaged. The areas will be regraded and revegetated.

Utilities that service other customers along the route to the plant site will be left in place. The portion of the utilities that extend onto the plant site will be removed if above ground, or remain in service depending upon the final use of the site. Below ground piping will be flushed as required, capped and left in place, if no longer in service.

3 Required Information

3.1 Introduction

The HCWPA has been prepared in accordance with the applicable sections of Chapter NR 812, Wis. Admin. Code, as it pertains to groundwater withdrawal activities. Extensive hydrologic work at the proposed CMC site has included in-situ hydraulic conductivity testing, a long-term pump test to define the relationship between the site bedrock and glacial overburden, and the development of a computerized model to predict the effect of the proposed mining operation on surface and groundwater resources. Investigations, studies, and significant research have been conducted for the project's EIR and permit applications and provide the basis for the hydrologic information used to support the HCWPA.

3.1.1 Water Use and Withdrawal

The development and operation of the proposed Crandon Project will require the managed withdrawal of groundwater flowing into the mine and the withdrawal of sufficient groundwater from wells, yet to be installed, for potable and non-potable water supply. A potable well will be needed for domestic and sanitary use at all mine facilities and for possible mitigation of Skunk Lake. The non-potable well will be needed for construction activities associated with the TMA.

In addition to the groundwater withdrawal directly associated with mining operations, a number of existing private domestic wells are located in the vicinity of the mine site. These wells also withdraw water from the unconsolidated glacial formations overlying the bedrock.

3.1.2 General Information

The owner of the proposed project is Crandon Mining Company, 7 North Brown Street, 3rd Floor, Rhinelander, Wisconsin 54501-3161. Jerome D. Goodrich, Jr., President, at (715) 365-1450 is the contact person for Crandon Mining Company. Crandon Mining Company will own and operate the mine and all wells associated with the project. Property ownership information within the project area is presented in detail within the project's MPA.

3.2 Mine Hydrology

A complete and detailed description of the geologic and hydrogeologic setting of the entire CMC site and the area over and immediately adjacent to the mine is presented in the Geology and Groundwater Sections of the project's EIR. The pertinent findings relevant to the HCWPA are highlighted below. Also, a description of mine development and dewatering and groundwater inflow control is included in Sections 2.3.1, 2.3.2 and 2.3.3 above.

The orebody is located between Little Sand Lake and Swamp Creek (Figure 2-2). The orebody is within bedrock. The upper portion of the bedrock surface and orebody is a saprolite layer of variable thickness. The saprolite layer is thickest in the vicinity of the orebody and has been delineated into a lower structured saprolite layer and an upper massive saprolite layer. The structured saprolite preserves the original rock structure but the mass of the rock has been largely altered to clay and iron oxides. The massive saprolite has the same appearance as the structured saprolite except that the original rock structure has been altered as a result of extreme

weathering. The boundary between massive and structured saprolite layers may be sharp or sometimes gradational.

The saprolite/bedrock unit is overlain by 75 to 250 feet of glacial deposits. The overburden consists primarily of three glacially derived units. The Pre- to Early Wisconsinan Till directly overlies the saprolite. The Till is overlain by glacial outwash which in turn is overlain by Late Wisconsinan Till.

Groundwater flow occurs in the glacial sediments overlying the bedrock and saprolite. The fine- and coarse-grained outwash deposits form the primary aquifer at the site because they are more permeable than all other units and they are regionally continuous. The Late and Pre- to Early Wisconsinan tills present above and below the outwash, respectively, inhibit groundwater flow.

Extensive field investigation and testing has been conducted to assess the hydraulic characteristics and properties of the bedrock, saprolite and overlying glacial materials. During the later part of 1994 and in the summer of 1995, respectively, a pump test and packer testing were performed by CMC to obtain additional data which would provide the basis for accurately estimating mine inflow and its quantitative effect upon the surrounding groundwater and surface water resources.

3.2.1 Regional Drawdown

As a part of the site investigation and evaluation, a predictive regional groundwater flow model was developed to simulate the effects of mine dewatering upon groundwater and surface water in the vicinity of the proposed mining operations. The model has been calibrated to reflect real-time data measured at the CMC site. Three conditions were evaluated for mine inflow conditions and include a low range estimate, a best engineering judgment (BEJ) estimate, and a practical worst case estimate. There is an equal probability that the low range and practical worst case mine inflows will occur. The BEJ case represents the conditions which are most likely to occur and has been used to evaluate drawdown conditions presented for this HCWPA.

The results of the modeling work are presented in the September, 1995, report prepared by GeoTrans, Inc., entitled, "Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Zinc and Copper Mine near Crandon, Wisconsin." This report is discussed in Section 4.2.5 of the project's EIR and reproduced in its entirety in Appendix 4.2-3 of the EIR. The results of the best BEJ flow simulation indicate that mine inflow at steady state will be approximately 600 gpm. The regional drawdown contours for the BEJ scenario are shown in Figure 3-1. The predominant source of groundwater inflow will be the overlying glacial outwash.

The model also indicates that the greatest drawdown will occur directly over the orebody, as shown in Figure 3-1. The 10-foot drawdown contour extends approximately 1,000 to 2,000 feet outward from the orebody in the north-south direction, and underneath Little Sand Lake. The estimated extent of the 2-foot drawdown contour, extends outward approximately 9,000 feet from the orebody to the west and south and approximately 5,000 feet to the north and 7,000 feet to the east.

3.2.2 Monitoring Mine Inflow

As described in Section 7 of the project's *Mine Permit Application*, the volume of water pumped from the mine will be recorded. Adjustments will be made to the data base to account for non-inflow water introduced into the mine through stope backfill dewatering, mine ventilation condensation, and the supply of potable water.

3.2.3 Alternative Mine Dewatering System

Numerous conservative assumptions have been incorporated into the project's regional groundwater modeling work. Based on these assumptions, the project's water balance for minimum conditions as presented on Figure 6-3 of the *Mine Permit Application* shows it is possible that very little discharge (<80 gpm) of treated project wastewaters could occur. It is also possible that actual mining conditions could result in less inflow than the conservative modeling has estimated, even under minimum conditions. In this event, it is possible that the mine inflow rate could be insufficient to meet the water makeup needs for the project's mill. If this condition were to occur, CMC would install a single well or a series of wells screened in the overburden over the ore body to provide the needed water. The capacity of this system would be approximately 200 gpm. Impacts associated with this water development plan, if needed, would be less than those estimated for the BEJ mine inflow case as discussed in Section 4 of the project's EIR and as shown on Figure 3-1 of this application.

3.3 Public and Private Water Supply Well Locations

CMC conducted an inventory of domestic water wells in the vicinity of the proposed mine in the summer of 1994. This inventory built upon two previous inventories of domestic water wells in the project vicinity. Dames and Moore conducted the first inventory in 1982 (Dames and Moore, 1982) and Northern Lake Services, Inc. (NLS) conducted a second inventory in 1984 (Northern Lake Service, 1984).

3.3.1 1982 and 1984 Inventories

For the 1982 inventory, Dames & Moore developed a system of numbering plats. Each well that was identified was assigned a number corresponding to the number of the plat on which the well was located. The water well inventory resulted in the identification of 42 wells within the inventory area. The information on these wells was obtained from well logs or from personal communication with well owners.

In 1984 NLS conducted an inventory of a 36-square-mile area surrounding the proposed plant site. The numbering system of the Dames & Moore inventory was adopted and the region was divided into four zones. Zone I corresponded to that area which was estimated to experience greater than one meter (3.3 feet) of drawdown from mine dewatering, based on modeling done at the time. Zone I is the shaded region in Figure 3-2. Zones II, III, and IV represented three outer boundary zones and are not shown. Within Zone I, scattered wells were assigned numbers 1 through 99, and wells clustered around Little Sand Lake were assigned numbers between 101 and 199. NLS supplemented the data collected by Dames & Moore with questionnaires to well owners. Owners who did not respond to the questionnaire were contacted by phone or in person. An effort was made to make on-site observations of all shallow-driven wells. Well driller reports provided by the Wisconsin Geologic and Natural History Survey (WGNHS)

provided most of the information on drilled wells. Information collection focused primarily on Zone I. Of 54 estimated wells in Zone I, information was collected on 52 wells. In the entire 36-square-mile inventory area, there were estimated to be 318 wells, and information was obtained on 211 of them.

3.3.2 1994 Inventory

The domestic water well inventory conducted in the summer of 1994 retained the numbering system of previous inventories. The inventory focused on Zone I (Figure 3-2) since preliminary results from the regional groundwater model at that time had indicated that the extent of drawdown from mine dewatering would be no greater than that estimated in the 1980s and likely would be less. Previously known wells were identified using the numbers they were assigned in the 1984 NLS inventory. Data from the NLS inventory were updated with a new survey of current landowners and with a new review of WGNHS files to identify new Well Construction Reports submitted since the last collection. Scattered new wells in Zone I were numbered following the 01 to 99 convention. New wells immediately surrounding Little Sand Lake were numbered using the 101 to 199 convention.

The inventory area included sections of both Forest County and Langlade County. The current Forest County Atlas and Plat Book and the current Langlade County Atlas and Plat Book were initially consulted to determine current land ownership. To further update the land ownership data from the plat books, the current Forest County treasury files and Langlade County treasury and real property lister files were consulted. From this information, the current property owners were identified in the inventory area. These property owners are listed in Table 3-1.

Since the 1984 inventory, many changes in land ownership had occurred. At the time of the survey, approximately 40 percent of the property in the inventory area was owned by CMC. This property included about 75 percent of the Little Sand Lake area, and a section unit to the immediate east, immediate north, and immediate west of Little Sand Lake. Properties purchased by CMC were not included in the survey because CMC plans to abandon any wells on these plats.

A questionnaire was prepared for mailing to all current landowners within the inventory area. Property owners were placed in one of three categories: existing property owners that participated in the 1984 survey (Original Owners), owners of property not previously surveyed in the area (New Owners), and new owners of property previously surveyed (Transferred Owners). A questionnaire was prepared for Original Owners, and a separate questionnaire was prepared for New Owners/Transferred Owners. A different cover letter was prepared for each of the three groups.

Original Owners were asked to describe any maintenance or changes to their well system since 1984. Maintenance changes referenced on the questionnaire included well replacement, relining the well, deepening the well, and pump replacement. New Owners and Transferred Owners were asked to provide general information about their well such as primary water use, method and date of well installation, pump type, well depth, well diameter, screen length, static water level, water level during pumping, and casing material. All owners were asked to give an opinion of the water quality of their wells in terms of taste, odor, and quantity.

Table 3-1

Property Owners and Domestic Water Wells in Inventory Area

Property Owner	Well Number	Form of Contact	Comments
Becker, William J.	108	phone	private well on property
Betters, William	118	returned survey	private well on property
Bishop, Joseph	--	returned survey	survey response not clear but appears no well
Bradley, Alicia	--	not reached	no Well Construction Report on file
Bradley, Wallace	--	not reached	no Well Construction Report on file
Buckley, Gerald	167	returned survey	private well on property
Campshure, James	--	returned survey	no well on property
Cheslock, Richard	--	returned survey	no well on property
Clark, Thomas	33	returned survey	private well on property
Connor, Richard M.	--	returned survey	no well on property
Consolidated Papers, Inc.	--	returned survey	no well on property
Cook, Ralph J.	--	returned survey	own well, but well appears to be outside Zone I
Dhuey, David J.	166	returned survey	private well on property
Dietzler, Ruth	115	returned survey	private well on property
Dilley, Lyon	--	not reached	no Well Construction Report on file
Dix, Beverly	114	returned survey	private well on property
Fishler, Grace	--	phone	well identified in 1984 NLS inventory but owner claims no well
Forest County	--	not reached	no Well Construction Report on file
Freye, William	--	returned survey	own well, but well appears to be outside Zone I
Fritsche, Franklin J.	107	returned survey	private well on property
George, Lloyd E.	--	returned survey	no well on property
Haferman, Ralph W.	106	returned survey	private well on property
Hess, John	--	returned survey	no well on property
Hockers, C.J.	--	not reached	no Well Construction Report on file
Hoffman, Cynthia	--	returned survey	well identified in 1984 NLS inventory but owner claims no well
Hoffman, David	--	returned survey	abandoned well on property
Hoffman, Jerome	--	returned survey	no well on property
Hoffman, Joan	--	returned survey	no well on property
Hoffman, Raymond H.	90, 91	returned survey	two private wells on properties; second well identified in 1984 NLS inventory
Jameson, John G., Jr.	--	phone	no well on property
Jansen, Jeff	32	returned survey	private well on property
Johnson, Archie	--	returned survey	no well on property
Johnson, Gary	162	returned survey	private well on property

Table 3-1 *(Continued)*

Property Owner	Well Number	Form of Contact	Comments
Kelchner, Robert M.	105, 105a	returned survey	two private wells on property; second well identified by Well Construction Report
Keppert, Gerald D.	--	returned survey	own well, but well appears to be outside Zone I
Kloehn, Gerald	168	returned survey	private well on property
Kriegel, Elmyra	89, 89a	returned survey	two private wells on property; second well identified in 1984 NLS inventory
Langlade County, C.F.L.	--	not reached	no Well Construction Report on file
Lijewski, Edward	144	returned survey	private well on property
Mantey, James P.	121	not reached	well identified in 1984 NLS inventory
Mihalko Land and Logging	--	phone	no well on property
Mihalko, Thomas	--	phone	no well on property
Menominee Indian Tribe of Wisconsin	68	not reached	Well Construction Report on file
Northern Woodlands, Inc.	--	not reached	no Well Construction Report on file
Noteboom, Maureen B.	--	returned survey	no well on property
Pallen, Herman	116	returned survey	private well on survey
Parker, R. W.	143	not reached	Well Construction Report on file
Phalen, Patrick, Jr.	57	returned survey	private well on property
Pieritz, Richard	102	returned survey	private well on property
Pryor, Harold	--	not reached	no Well Construction Report on file
Schallock, Jerry L.	145	returned survey	private well on property
Schmidt, John	87, 87a	returned survey	two private wells on property
Schrading, Mark	--	returned survey	no well on property
Schultz, Delores	--	returned survey	no well on property
Seawell, Elizabeth	--	not reached	no Well Construction Report on file
Sokaogon Chippewa Community	--	not reached	no Well Construction Report on file
Solper, Gerald K.	--	returned survey	own well, but well appears to be outside Zone I
State of Wisconsin	--	not reached	no Well Construction Report on file
Streur, William	--	not reached	no Well Construction Report on file
Tambellini, Thomas	--	returned survey	no well on property
Terzinski, Kathy	--	phone	no well on properties within Inventory Area
Thornton, Thomas J.	--	not reached	no Well Construction Report on file
Tomahawk and Timber	--	not reached	no Well Construction Report on file
Torgerson, Bernie	--	returned survey	own well, but well appears to be outside Zone I
Verlotta, Joseph	--	not reached	no Well Construction Report on file

Table 3-1 *(Continued)*

Property Owner	Well Number	Form of Contact	Comments
Walentowski, Clement	84, 92, 93, 119	returned survey	four private wells on properties; survey mentioned one well; others identified in 1984 NLS inventory
Walentowski, Harold	--	phone	well identified in 1984 NLS inventory but owner claims no well
Webb, Richard	--	not reached	owned well 102 but sold section to Pieritz
Weiland, R.	--	not reached	no Well Construction Report on file
Wisconsin DNR	--	not reached	no Well Construction Report on file
Wisconsin Timber Association	--	returned survey	no well on property
Yeager, Florence Ann	120	returned survey	private well on property
Younk, G.	--	returned survey	no well on property

-- No well known to be located on property.

Prepared by: JJA1
Checked by: XXC

On July 11, 1994, questionnaires and cover letters were mailed to area property owners. On August 1, 1994, all owners who failed to respond to the July 11 questionnaires were mailed a second questionnaire. An attempt was made to contact by telephone each landowner who did not respond to either questionnaire.

In addition to the questionnaires, a review of WGNHS files for Well Construction Reports on properties in the inventory area was requested. Only Well Construction Reports up to 1990 were available. More current reports were still being sorted by WGNHS at the time of request.

3.3.3 Summary of Inventory Results

Of the 73 wells in the inventory area not owned by CMC, responses were received from 52 owners. Questionnaires were returned by 45 owners, and seven owners were reached by telephone. The remaining 21 landowners were not reached. However, of the 21, there is no well construction report on file for 17 of the properties, construction reports were noted for two properties, and one property had a well noted in the 1984 NLS inventory. Additional efforts to contact the remaining 21 landowners will be made to verify the inventory in Table 3-1.

Among those landowners reached, 30 wells were identified in the inventory area. Additionally, three wells were identified from Well Construction Reports or from the 1984 NLS inventory on properties belonging to owners who could not be reached. These wells were assumed to still be in operation. Thus, a total of 33 domestic wells were listed in the inventory. Some of the landowners own several pieces of property in the inventory area. Others own additional properties outside of the inventory area or own properties that extend off the inventory area. When these landowners answered the questionnaire, it was not always clear which specific property their well was located on or even if the well was located in the inventory area. Table 3-1 lists the response of each property owner to the survey, and any special notes or

uncertainties related to their wells or property. Figure 3-1 shows well locations for the entire inventory area. Figure 3-3 shows well locations immediately surrounding Little Sand Lake. Information on those wells which have been identified is summarized in Table 3-2. Since the July of 1994 survey, CMC has acquired purchase options for a number of the properties containing the wells listed in Table 3-2. These properties are associated with well number 102, 115, 116, 118, 120, 162, 167, and 168.

Generally, the wells in the area are shallow. The average well depth is approximately 35 feet. The deepest is 96 feet. In most cases the static depth to water is less than 30 feet, but in one well the static depth to water was 72 feet. The oldest well was installed in approximately 1948, with the newest installed in 1993. Most are driven wells, although some are drilled wells. Most use shallow well type pumps and nearly all are used for private domestic purposes. They draw from aquifers in either the undifferentiated Late Wisconsinan Till or the underlying outwash deposits. Most well owners are of the opinion that the water provided by their well is of good quality and there are very few problems with taste, staining, odor, or insufficient flow. A few well owners reported that in their opinion their well had some degree of problem with iron.

3.4 Description of Existing CMC Wells

Of the CMC owned wells (those installed by CMC and those residential wells purchased by CMC) only Wells No. 101, WW-1, and WW-2, Figure 3-4, are presently used, and then only on an intermittent basis to support field study activities.

The residential well identified as No. 101 is owned by CMC and used occasionally by CMC or CMC contractors, however there is no one permanently residing at the house. Water use is estimated at less than 100 gallons per day (gpd). WW-1 and WW-2 have been previously used to supply non-potable water to support drilling activities on the site on an intermittent basis. Detailed descriptions of the construction and disposition of WW-1 and WW-2 are presented in Table 3-3. During drilling activities water usage from WW-1 and WW-2 average between approximately 1,000 to 20,000 gpd.

The use of wells 101, WW-1 and WW-2 will continue throughout the construction phase of the project. At the onset of the mining operation there will be two permanent wells installed, which will be known as the "potable" well and "TMA" well. When the permanent wells are put in place all other wells owned by CMC, with the exception of monitoring wells, will be abandoned in accordance with applicable regulations.

3.5 Construction of New CMC Water Supply Wells

3.5.1 Potable Well Location and Use

A new potable well will be constructed approximately one-half mile south of the plant site, approximately 1,200 feet northwest of Little Sand Lake. This well, as shown on Figure 3-5, will be located in a relatively undeveloped area in the SE¼ of the NE¼ of Section 36, T35N, R12E Nashville Township (State Plane Coordinates 114,278N 2,275,384E) at an approximate ground elevation of 1,662 feet MSL. It will be the sole supplier of potable water to the project's various facilities. If and when mitigation of Skunk Lake needs to be implemented, this well will also be used for that purpose. Water from the well will be transported to a tank, constructed at an approximate ground elevation of 1,658, located at the plant site via an approximate 1.1-mile long supply pipeline as shown in Figures 3-5, 3-6 and 3-7. The pipeline reaches a maximum elevation of 1,677 feet MSL along the pipeline route between the well and the tank, which is approximately 5.6 feet below the top of tank elevation. The 6-inch diameter buried pipeline will be a forcemain to allow transfer of water from the well location to the tank. No other alternative water supply systems that are

Table 3-2

Description of Domestic Water Wells in Inventory Area

	Well Number	Location	Water Use	Year of Installation	Installation Method	Well Details: Depth (ft.)	Well Details: Diam. (in.)	Well Details: Screen (ft.)	Depth to Water (ft): Static	Depth to Water (ft): Pumping	Casing Material	Pump Type	Water Quality (Owner's Opinion)	Description of Well Repairs
Jansen, Jeff	32	S4-T34N-R13E	Private	1993	Driven	12	1.75	3	--	--	Galv.	Hand Pump	Good taste, very clear	none
Clark, Thomas	33	S4-T34N-R13E	Private	1988	Driven	25	2	--	--	--	Galv.	Shallow Well	Excellent, almost no mineral taste, no odor, minimal staining	Pump replaced - 02/94
Phalen, Patrick	57	S35-T35N-R12E	Private	1991	Drilled	60	6	3	45	--	--	Submersible	Very clear	N/A
Morgan, Andrew H.	68	S25-T35N-R12E	Private	1988	Drilled	83.5	6	3	72	75	Blk Steel	--	--	
Walentowski, Clement	84	S26-T35N-R12E	Private	--	Driven	26	1.25	--	14	--	Galv.	--	Good	
Schmidt, John	87	S26-T35N-R12E	Private	Unknown	Driven	28	1.25	--	--	--	Galv.	--	Taste OK, no odor, very little staining	New pump motor, point and pipe
Schmidt, John	87a	S25-T35N-R12E	Private	1993	Drilled	31	6	3	--	--	Steel	Submersible	Taste OK, no odor	
Kriegel, Elmyra	89	S26-T35N-R12E	Private	1960 (est)	Driven	20	1.25	3	20	--	Galv.	Shallow Well	Taste OK, no odor, hard	Well not in use
Kriegel, Elmyra	89a	S26-T35N-R12E	Private	--	Driven	20	1.25	3	--	--	Galv.	No Pump	Rusty, bacteriologically unsafe	Not in use
Hoffman, Raymond H.	90	S26-T35N-R12E	Private	1948 (est)	Driven	27	1.25	4	21	--	Galv.	Shallow Well	Good, slightly hard	Not repaired or re
Hoffman, Raymond H.	91	S26-T35N-R12E	Private	--	Driven	28	1.25	4	22	--	Galv.	Shallow Well	Excellent	Not repaired or re
Walentowski, Clement	92	S26-T35N-R12E	Private	--	Drilled	63	5	3	14	19	Blk Steel	Shallow Well	Good taste, no odor, some rust	

Table 3-2 *(Continued)*

	Well Number	Location	Water Use	Year of Installation	Installation Method	Well Details: Depth (ft.)	Well Details: Diam. (in.)	Well Details: Screen (ft.)	Depth to Water (ft): Static	Depth to Water (ft): Pumping	Casing Material	Pump Type	Water Quality (Owner's Opinion)	Description of Well Repairs
Walentowski, Clement	93	S26-T35N-R12E	Domestic Commercial	--	Driven	28	1.25	3	20	--	Galv.	Shallow Well	Iron taste and color	
Pieritz, Richard	102[1]	S36-T35N-R12E	Private	1959	Drilled	58	4	3	25	45	Std. Steel	Deep Well Jet	Good, some iron	None
Kelchner, Robert M.	105[1]	S36-T35N-R12E	Private	1977	Drilled	54	6	3	21	26	ASTMA 53	Submersible	Excellent	No repairs
Kelchner, Robert M.	105a[1]	S36-T35N-R12E	Private	1962	Driven	22	2	2	--	--	Galv.	Shallow Well	Good, clear, soft	
Haferman, Ralph W.	106	S36-T35N-R12E	Private	1956	Driven	17	1.25	--	5	--	Galv.	Shallow Well	Okay	None
Fritsche, Franklin J.	107	S36-T35N-R12E	Private	1961	Driven	20	1.25	4	14	--	Galv.	Shallow Well	Excellent quantity - good taste, no odor	Pump replaced - 06/89 new point 06/90
Becker, William J.	108	S36-T35N-R12E	Private	1965	Driven	25	1.25	--	--	--	Galv.	--	Good, clear	
Dix, Beverly	114	S35-T35N-R12E	--	--	Driven	18	--	--	--	--	--	--	Good tasting and very clear	New pump
Dietzler, Ruth	115[1]	S36-T35N-R12E	Private	1968	Driven	20-30	1.25	--	--	--	--	Shallow Well	Good taste, no odor, no iron staining	None
Pallen, Herman	116[1]	S36-T35N-R12E	Private	--	Driven	23	1.25	3	6	--	Galv.	--	Water is clear, tastes excellent, no iron	
Betters, William	118[1]	S36-T35N-R12E	Private	1978	Driven	23	1.25	--	6	--	Galv.	Shallow Well	Good, no odor	None
Walentowski, Clement	119	S36-T35N-R12E	Private	--	Drilled	20-30	3	--	11	--	--	Shallow Well	Not the best taste	
Yeager, Florence Ann	120[1]	S36-T35N-R12E	Private	--	Driven	30	1.25	3	25	--	Galv.	Shallow Well	Pure water - not hard, good taste	Pump Replaced
Mantey, James P.	121	S31-T35N-R13E	Private	1970	Driven	24	1.25	4	--	--	Galv.	Shallow Well	Good, clear	

Table 3-2 *(Continued)*

	Well Number	Location	Water Use	Year of Installation	Installation Method	Well Details: Depth (ft.)	Well Details: Diam. (in.)	Well Details: Screen (ft.)	Depth to Water (ft): Static	Depth to Water (ft): Pumping	Casing Material	Pump Type	Water Quality (Owner's Opinion)	Description of Well Repairs
Parker, R. W.	143	S31-T35N-R13E	Private	1977	Drilled	64	5	3	23	--	Galv.	Submersible	Good	
Lijewski, Edward	144	S31-T35N-R13E	Private	1975	Drilled	58	5	2	23	50	Blk steel	Submersible	Excellent, clear water	None
Shallock, Jerry L.	145	S31-T35N-R13E	Private	1974	Drilled	96	0.5	--	20	--	--	Submersible	Good taste, some iron	No Repairs
Johnson, Gary	162[1]	S6-T34N-R13E	Private	--	--	--	--	--	--	--	--	--	No problem.	No Repairs.
Dhuey, David J.	166	S6-T34N-R13E	Private	--	Driven	32	2	--	25	--	Galv.	Deep Well Jet	Good, no problems	No repairs.
Buckley, Gerald	167	S6-T34N-R13E	Private	1980	Drilled	57	5	2	26	50	Blk Steel	Submersible	Very good taste, no odor, little staining, sufficient quantity	None
Kloehn, Gerald	168[1]	S36-T35N-R12E	Private	--	Drilled	37.5	4	--	23	--	N/A	No Pump	--	No Repairs

[1]CMC land purchase option obtained since the 1994 well inventory.

Prepared by: CH
Checked by: JJA1

Table 3-3

Description of the Design of Existing Wells WW-1 and WW-2

WW-1 located SE ¼ of SW ¼, Section 30, T25N, R13E

Ground Surface Elevation	- 1,670 feet M.S.L.
Well Depth	- 130 feet.
Casing Size	- 8-inch diameter steel; record of steel type not available.
Depth of Casing	- 120 feet plus 5 feet of 2-slot Johnson stainless steel screen plus 5 feet of tail pipe with K packer.
Casing Thickness	- Schedule 40 pipe (threads and couplings); record of actual wall thickness not available.
Geologic Formation	- Well totally in glacial sand and gravel; primarily coarse gravel with minor clay content.
Grouting	- None.
Water Levels	- Static - Approximately 1,588 feet M.S.L.
Date Constructed	- July, 1976.
Pump Installation	- Submersible pump with approximately 15-gpm capacity connected to a buried 10,000 gallon storage tank. Pump with approximate 40-gpm capacity installed on tank.
Driller and Owner	- Drilled by Anderson Well Drilling, Inc., owned by CMC.
Current Use	- During field drilling activities (approximately four months per year during the past few years). Combined water usage of WW-1 and WW-2 has averaged approximately 1,000 gpd. On an annual basis this equates to approximately 330 gpd.
Future Status	- After installation of the potable well, the pumping system and storage tank WW-1 will be removed and abandoned according to state regulations.

WW-2 located SE ¼ of SE ¼, Section 25, T25N, R12E

Ground Surface Elevation	- 1,644 feet M.S.L.
Well Depth	- 155 feet.
Casing Size	- 8-inch diameter steel; record of steel type not available.
Depth of Casing	- 145 feet casing plus 5 feet of 2-slot Johnson stainless steel screen plus 5 feet of tail pipe with K packer.
Casing Thickness	- Schedule 40 pipe (threads and couplings); record of actual wall thickness not available.
Geologic Formation	- Well totally in glacial overburden sand and gravel.
Grouting	- None.

Table 3-3 *(Continued)*

Water Levels	- Static - Approximately 1,578 feet M.S.L.
Date Constructed	- September, 1976.
Pump Installation	- Submersible pump with approximate 60-gpm capacity.
Driller and Owner	- Drilled by Anderson Well Drilling, Inc., owned by CMC.
Current Use	- See comments for WW-1.
Future Status	- After installation of the potable well, the pumping system will be removed and WW-2 will be abandoned according to state regulations.

Prepared by: BDH
Checked by: PAE

economically feasible exist. For instance, the project area is not serviced by a municipal water supply system and trucking water in would be impractical and more costly than constructing the proposed well.

The new potable well will be constructed in accordance with the provisions of Chapter NR 812, Wis. Admin. Code. A written well construction report will be submitted to the WDNR within 30 days of well construction. Estimated average usage from this well will be approximately 25 gpm for potable water and approximately 68 gpm if it is used for mitigation and potable water. A discussion of site geology and well construction follows.

3.5.1.1 Site Geology

A summary of the general regional and site geology is presented in Section 3.5 of the project's EIR. A log for a boring near the proposed well location is presented in Appendix A. This boring, DMP-3, is located at State Plane Coordinates 113,665N 2,275,625E. The position of this boring in proximity to the proposed potable well is shown on Figure 3-5.

3.5.1.2 Specifications for the Potable Well Construction and Pump Installation

The details of the proposed construction of the potable well are illustrated on Figure 3-8. Specifications for the construction of this well and installation of the pump are provided in Appendix B. The drilling method to be used for well construction will be selected by the contractor based on site geology. The sampling faucet for the potable well will be located at the plant site adjacent to the water storage tank. A WDNR-approved pitless adapter will be used. Pressure testing will be performed for pitless adapter location before use.

3.5.2 TMA Well Location and Use

The TMA well location is shown on Figure 3-5. The well will be located approximately 200 feet north of the north-west corner of the TMA in the NW¼ of the SE¼ of Section 29, T35N, R13E of Nashville Township (State Plane Coordinates 117,754N 2,284,280E) at an approximte ground elevation of 1,670 feet MSL. This well will be used for processing site glacial material and wash plant operations during the construction phases of the TMA, estimated to occur approximately every three years. The normal groundwater consumption estimate for this well is based on 12-hour days during construction years. Till processing and other miscellaneous uses will use 200 gpm for approximately 100 days, while the wash plant will use 300 gpm for approximately 40 days. This averages to 114 gpm for the 140 day interval anticipated to be required for TMA construction material processing.

The well location is within 300 feet of the TMA and will require a variance from the siting requirements outlined in Chapter NR 812.08, Wis. Admin. Code. This variance is justified since the periodic use at the TMA well will result in a negligible drawdown and the water table will recover between planned usage periods which are spaced at approximately 3-year intervals.

3.5.2.1 Site Geology

A summary of the general regional and site geology is presented in Section 3.5 of the EIR. A log for a boring near the proposed well is presented in Appendix A. This boring, G41-H9, is located at State Plane Coordinates 117,330N 2,285,000E. The position of this boring in proximity to the proposed TMA well is shown on Figure 3-5.

3.5.2.2 Specifications for the TMA Well Construction and Pump Installation

The details of the proposed construction of the TMA well are illustrated on Figure 3-9. Specifications for the construction of this well and installation of the pump are provided in Appendix B. The drilling method to be used for well construction will be selected by the contractor based on site geology. The TMA well will be located within a small well house. A sampling faucet will be provided to allow sample collection at the well head.

3.5.3 Monitoring Program

Details of the project's groundwater monitoring program are contained in Section 7 of the *Mine Permit Application*. The CMC project site will have an extensive network of groundwater monitoring wells which will be sampled and measured on a scheduled basis to detect changes in groundwater quality and fluctuations in water table elevations. As related to the potable well, changes detected in the site-wide monitoring network will provide advance notice of changes in upgradient groundwater quality. In accordance with Chapter NR 812, Wis. Admin. Code, the proposed potable well will be tested for bacteriological safety before it is put into service.

4 Groundwater Withdrawal Impacts

4.1 Groundwater Withdrawal Impacts on Private Wells

Based on a review of the project's groundwater modeling results and the surveyed private wells, it is concluded that only wells located within areas with more than a 4-foot drawdown have the potential to be affected by the project. Using this criteria, there are 12 private wells located on 11 properties which are not currently owned by CMC that could be affected by the estimated drawdown resulting from mine dewatering. These wells are listed in Table 4-1. The location of the wells are shown on Figure 3-10.

A groundwater monitoring program will be in place to measure changes in area water table elevations long before any impacts occur to private wells. Well modifications or replacement will be made by CMC based on the need demonstrated by the monitoring program. If practical, the existing pump will be lowered in the existing well to a depth that will allow continuous use. If this measure is impractical, then the well will be deepened and the pump lowered. If the existing well cannot be modified, than a new well can be constructed to a depth that will provide a reliable quantity and quality of groundwater.

4.2 Groundwater Withdrawal Impacts on Water Bodies

Potential groundwater withdrawal impacts to lakes and streams have been estimated by the project's regional groundwater model. Based on this work, it was determined that it will be necessary to supplement water flow to Skunk Lake to replace water that will likely be lost due to mine dewatering. CMC has developed a mitigation plan which will be implemented once groundwater withdrawal impacts are observed in the vicinity of Skunk Lake. This plan is presented in Section 4.12.3 of the project's *Mine Permit Application* and includes the installation of a water discharge line from the plant site to Skunk Lake to allow the discharge of conditioned groundwater from the potable well into the lake.

Also presented in the *Mine Permit Application* are monitoring plans which will be used to monitor the extent of drawdown. Such monitoring will enable CMC to assess which provisions of the project's contingency plan (outlined in Section 8 of the *Mine Permit Application*) will need to be implemented.

4.3 Potable and Non-potable Well Drawdown Impacts

An assessment of the estimated drawdown caused by the potable and TMA non-potable wells was completed. The results of the assessment are presented in Appendix C. The first simulation estimated the affect of steady state pumping at 68 gpm for the potable well. The affect of the second simulation estimated a transient pumping rate of 114 gpm for the TMA well, assuming the average rate for each pumping cycle lasts 140 days. The simulations estimated the maximum drawdown for each well location. The results for each simulation are discussed below.

The first simulation considers a potable production well near Little Sand Lake that will pump at 68 gpm which includes 25 gpm for potable use and 43 gpm for Skunk Lake mitigation. The well will be screened in the outwash. The modeling results show the steady state drawdown from the potable well are in addition to the drawdown resulting from the dewatering as presented in

Table 4-1

Domestic Wells Potentially Affected by Groundwater Withdrawal

Domestic Well Owner	Well Number
Becker, William J.	108
Betters, William[1]	118
Buckley, Gerald[1]	167
Dhuey, David J.	166
Dietzler, Ruth[1]	115
Fritsche, Franklin J.	107
Haferman, Ralph W.	106
Johnson, Gary[1]	162
Kelchner, Robert M.	105
Kelchner, Robert M.	105a
Kloehn, Gerald[1]	168
Lijewski, Edward	144
Mantey, James P.	121
Menominee Tribe of Wisconsin	68
Pallen, Herman[1]	116
Parker, R. W.	143
Pieritz, Richard[1]	102
Schallock, Jerry L.	145
Walentowski, Clement	119
Yeager, Florence Ann[1]	120

[1]A land purchase option has been obtained by CMC for these properties.

Prepared by: JJA1
Checked by: XXC

Section 3.2.1. Maximum drawdown near the well is estimated to be three feet. The 2-foot contour extends out a distance of approximately 100 feet from the well. The simulation results demonstrate that the proposed well use will not result in any additional impacts to private wells or observable changes or impacts to water bodies.

The second simulation considers a non-potable well proposed near the TMA that will pump intermittently as follows:

For 100 days at 200 gpm for 12 hours/day
For 40 days at 300 gpm for 12 hours/day.

This cycle is expected to occur every three years. The model simulation used a pumping rate of 114 gpm to represent an average rate for each pumping cycle lasting 140 days. The well will be screened in the outwash. The modeling results show that the simulated transient drawdown at the end of a 140-day cycle on the TMA well is in addition to the drawdown results from mine dewatering as presented in Section 3.2.1. Maximum drawdown near the well is 11.8 feet. The 2-foot contour extends out a distance of approximately 1,200 feet from the well. The simulation results for the transient TMA well demonstrate that the proposed well use will not result in any additional impacts to private wells or any observable changes or impacts to water bodies.

5 References

Dames & Moore, 1982. *Groundwater Study and Study Methods.*

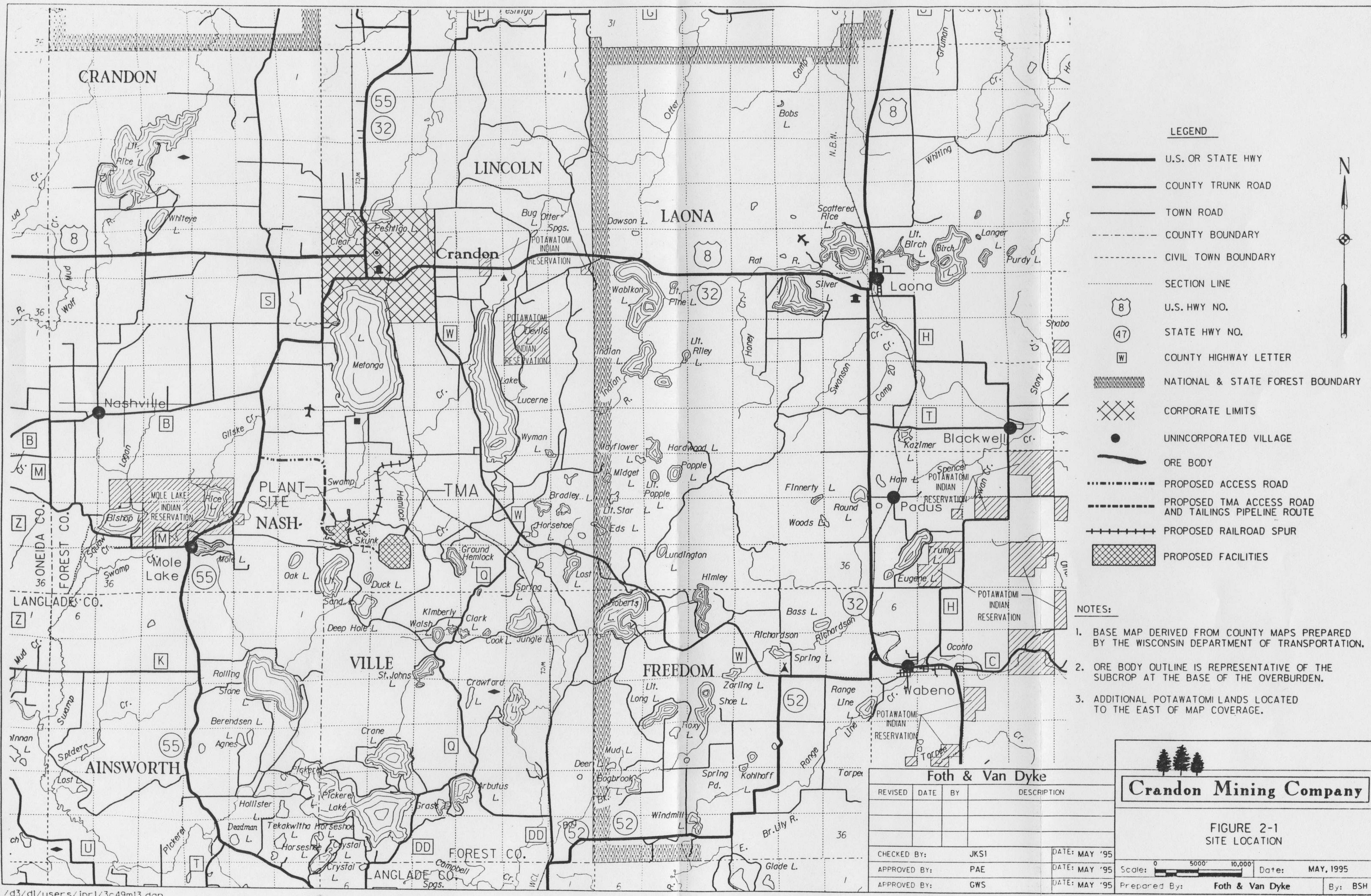
Foth & Van Dyke, May, 1995a. *Environmental Impact Report.*

Foth & Van Dyke, May 1995b. *Mine Permit Application for the Crandon Project.*

GeoTrans, September, 1995. *Numerical Simulations of the Effect on Groundwater and Surface Water of the Proposed Zinc and Copper Mine near Crandon, Wisconsin.*

Northern Lake Service, Inc., 1984. Private Well Survey.

FIGURES FOR HIGH CAPACITY WELL PERMIT APPLICATION



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

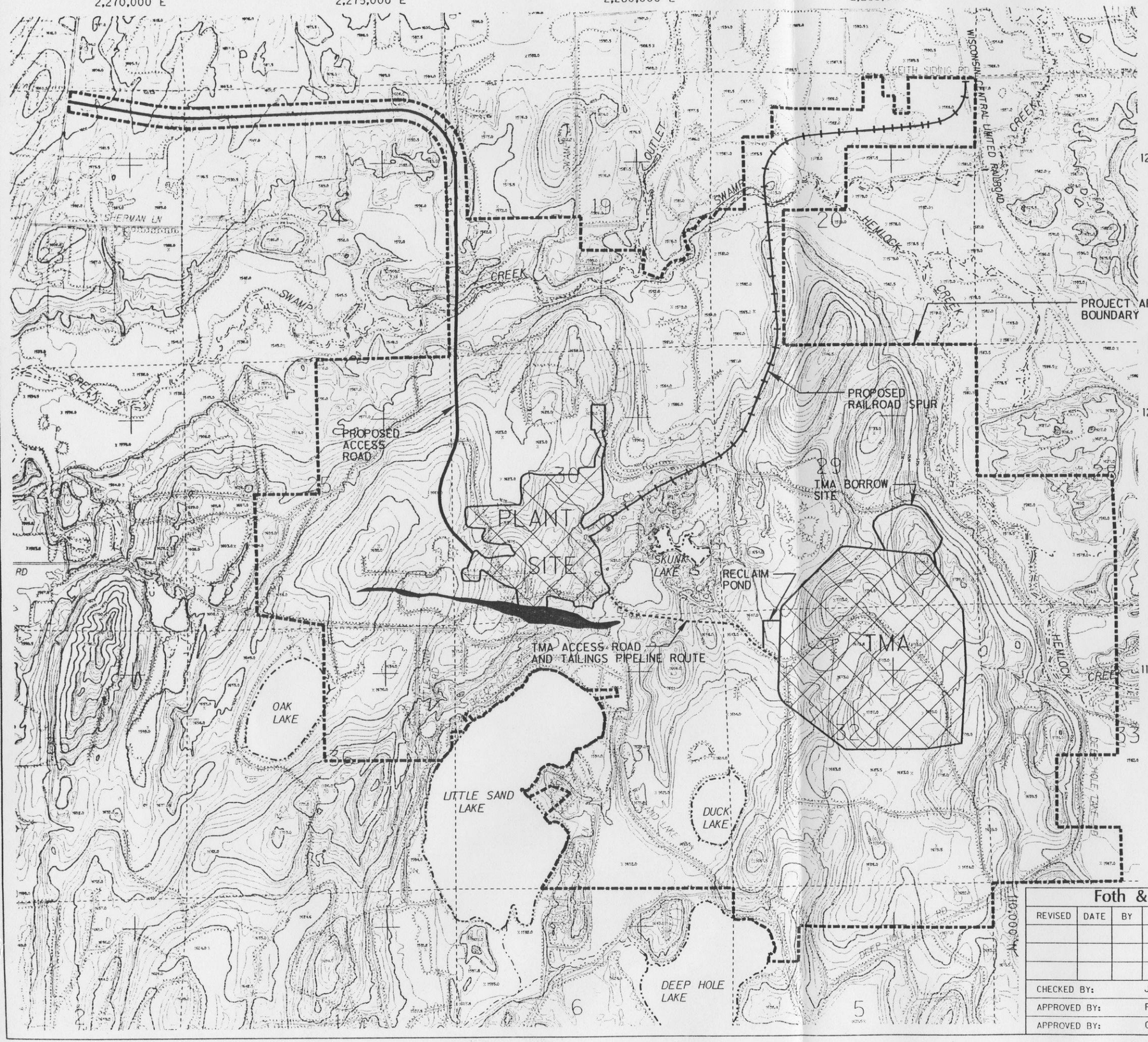
CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 2-1
SITE LOCATION

Scale: 0 5000' 10,000' | Date: MAY, 1995
Prepared By: Foth & Van Dyke | By: BSH

93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- x 1692.0 — EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 2-2
PROJECT AREA

Scale: 0 1000' 2000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JRB

93C049

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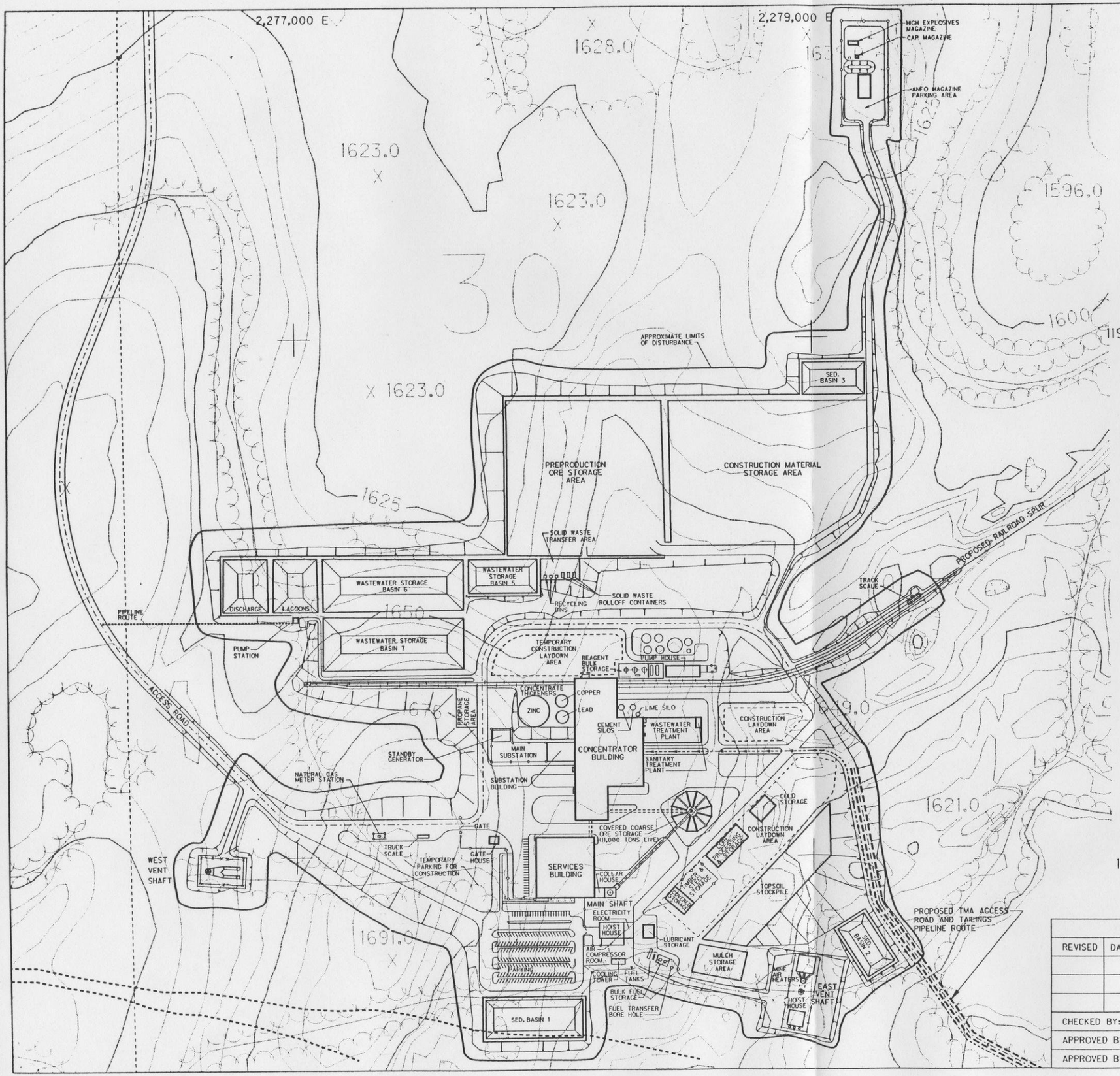


LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- X 1692.0 SPOT ELEVATION
- SECTION LINE
- ORE BODY

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

SCALE
0 200' 400'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

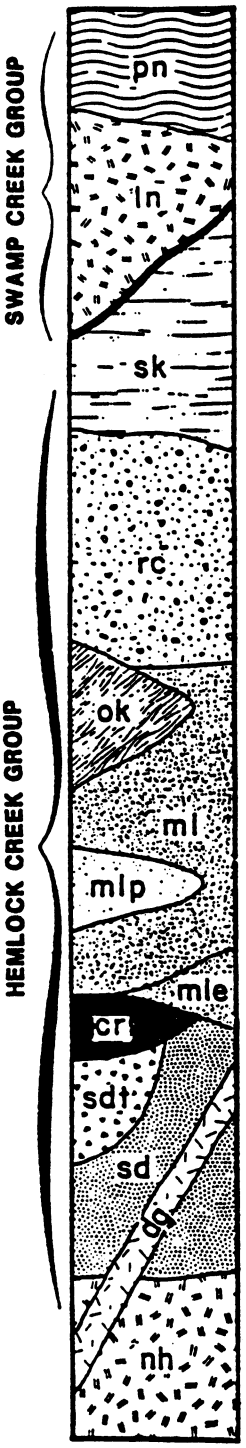
CHECKED BY:	JKSI	DATE: MAY.'95
APPROVED BY:	PAE	DATE: MAY.'95
APPROVED BY:	JWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 2-3
PLANT SITE LAYOUT

Scale: SEE BAR SCALE | Date: MAY, 1995
Prepared By: Foth & Van Dyke | By: JRB2

93C049



PINE FORMATION (pn)
Cherty tuff and argillite.

LINCOLN FORMATION (ln)
Quartz porphyritic rhyolite flows with minor interflow tuff, chert and argillite.

SKUNK LAKE FORMATION (sk)
Predominantly fine to coarse ash chert tuff, some cherty and very minor argillite.

RICE LAKE FORMATION (rc)
Volcanic debris flows (blocky chloritic and minor siliceous lapilli and breccia size debris) and eutaxitic ash flows, some chert.

OAK LAKE FORMATION (ok)
Sequence of cherty tuff and sericitic tuff.

MOLE LAKE FORMATION (ml)
Predominantly mafic ash tuff.

PROSPECT MEMBER (mlp)
Volcanic debris flow consisting of siliceous, lapilli size debris.

EAGLE MEMBER (mle)
Volcanic greywacke.

CRANDON FORMATION (cr)
Laminated, bedded & replacement sulfides (zinc ore) interbedded with pyritic argillite, pyritic felsic tuff and chert.

SAND LAKE FORMATION (sd)
Sequence of fine felsic tuffs and minor felsic debris & lava flows.

TOWNSHIP MEMBER (sdt)
Volcanic vent breccia affected by multiple stage hydrothermal alteration and sulfide enrichment.

NASHVILLE FORMATION (nh)
Feldspar porphyritic mafic flows.

DUCK LAKE GABBRO (dg)
Fresh, 2 pyroxene gabbro.
Cross cuts nh and sd.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	APR.'95
APPROVED BY:	PAE	DATE:	APR.'95
APPROVED BY:	GWS	DATE:	APR.'95

Crandon Mining Company

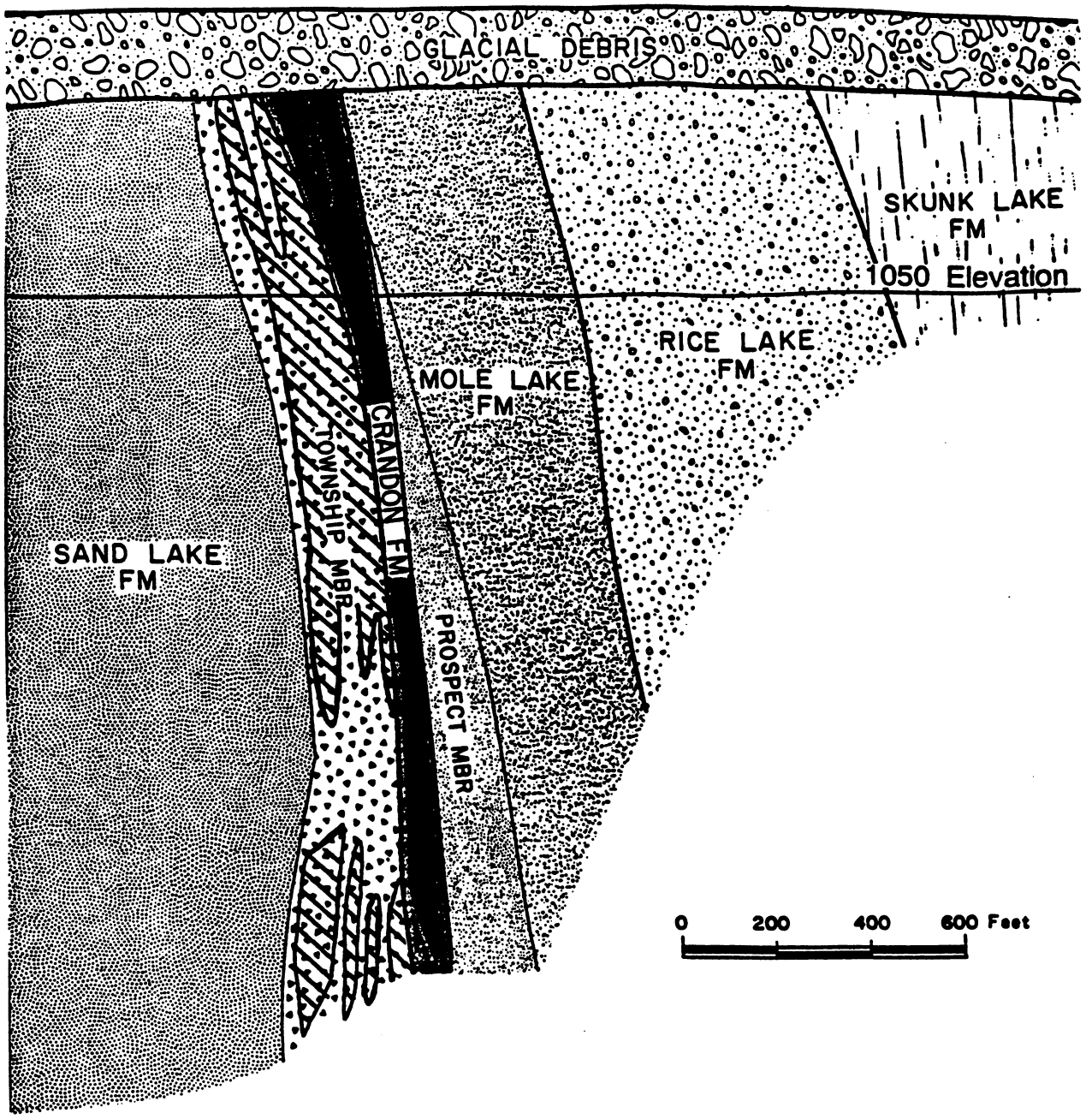
FIGURE 2-4
STRATIGRAPHIC COLUMN

Scale:	NOT TO SCALE	Date:	MARCH, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jprl/3c49m5.dgn

93C049

LOOKING WEST



ZINC ORE

COPPER ORE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: APR.'95
APPROVED BY:	PAE	DATE: APR.'95
APPROVED BY:	GWS	DATE: APR.'95

Crandon Mining Company

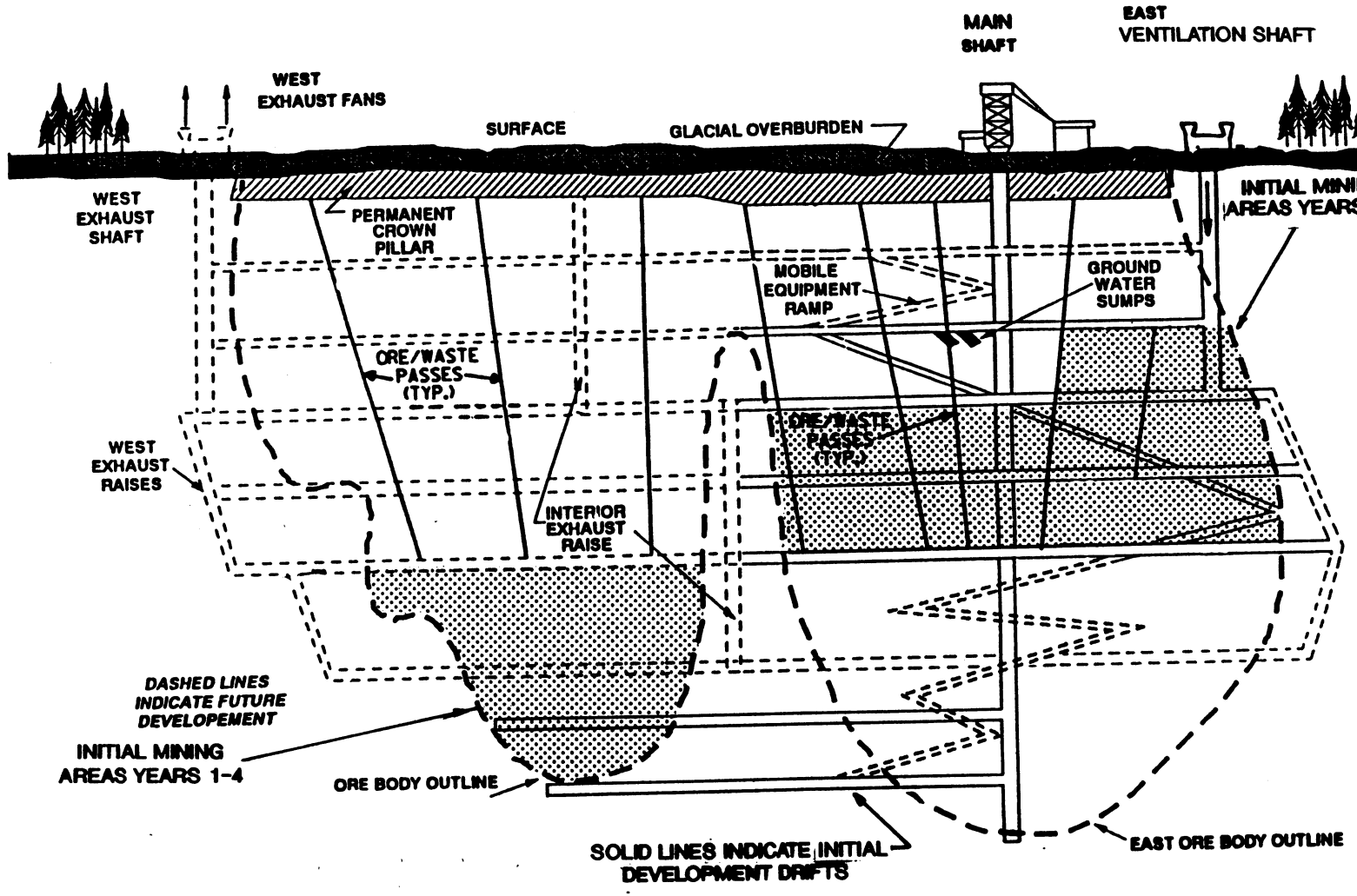
FIGURE 2-5

GENERALIZED GEOLOGIC CROSS SECTION C-C'

Scale:	AS SHOWN	Date:	MARCH, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jpr1/3c49m5.dgn

93C049



Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: APR.'95
APPROVED BY:	PAE	DATE: APR.'95
APPROVED BY:	GWS	DATE: APR.'95

Crandon Mining Company

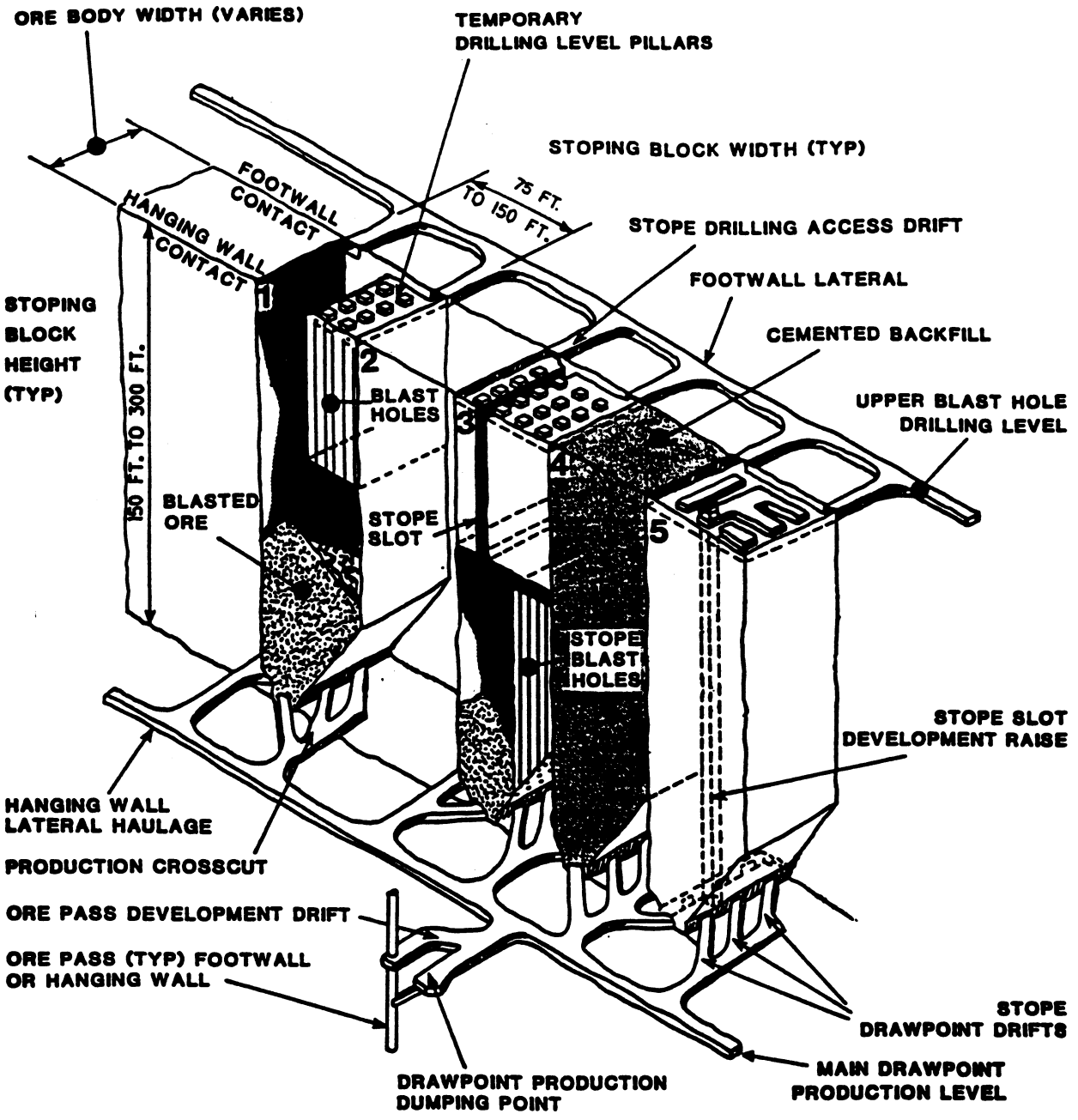
FIGURE 2-6

SCHEMATIC LONGITUDINAL SECTON (LOOKING NORTH)

Scale:	NOT TO SCALE	Date:	MARCH, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jpr1/3c49m5.dgn

93C049



STOPING BLOCK NO. 1-ACTIVE PRODUCTION-STOPE BLASTING NEARING COMPLETION

STOPING BLOCK NO. 2-ALTERNATE STOPING BLOCK/PILLAR-TO BE MINED AFTER BACKFILLING ADJACENT STOPES

STOPING BLOCK NO. 3-ACTIVE PRODUCTION-INITIAL STAGES OF STOPE BLASTING

STOPING BLOCK NO. 4-DEPLETED STOPE BLOCK-CEMENTED BACKFILL IN PLACE

STOPING BLOCK NO. 5-STOPE BLOCK PARTIALLY DEVELOPED

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REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: APR.'95
APPROVED BY:	PAE	DATE: APR.'95
APPROVED BY:	GWS	DATE: APR.'95

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FIGURE 2-7

CONCEPTUAL STOPING SEQUENCE

Scale:	NOT TO SCALE	Date:	MARCH, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

93C049

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REVISED	DATE	BY	DESCRIPTION

Foth & Van Dyke

CHECKED BY: JKSI DATE: APRIL '95

APPROVED BY: PAE DATE: APRIL '95

APPROVED BY: GWS DATE: APRIL '95

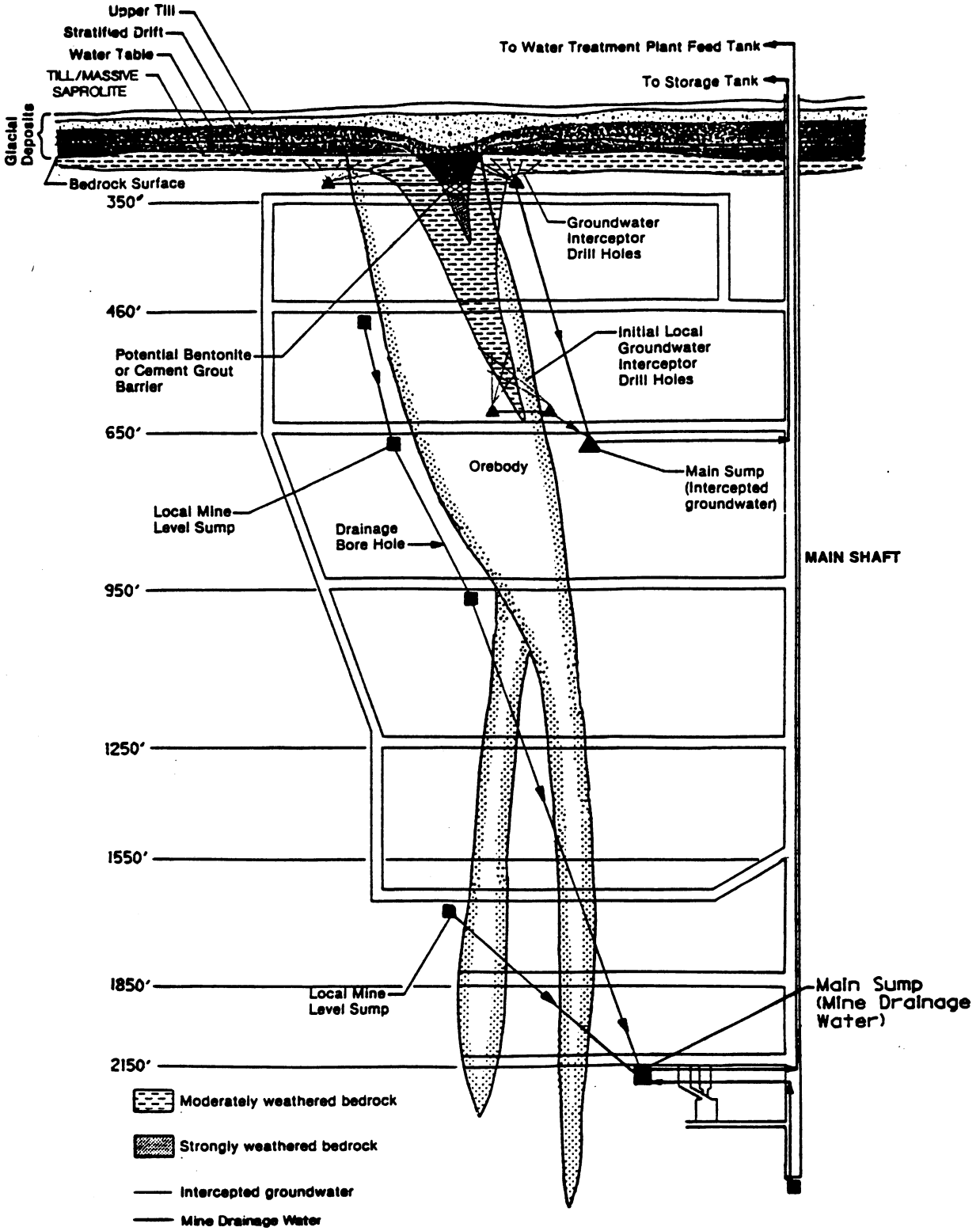
Crandon Mining Company

FIGURE 2-8

GROUNDWATER INTERCEPTOR SYSTEM
(CONCEPTUAL CROSS SECTION)

Prepared By: Foth & Van Dyke | Scale: AS SHOWN | Date: MARCH, 1995 | By: BSH

93C049



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	APR.'95
APPROVED BY:	PAE	DATE:	APR.'95
APPROVED BY:	GWS	DATE:	APR.'95

Crandon Mining Company

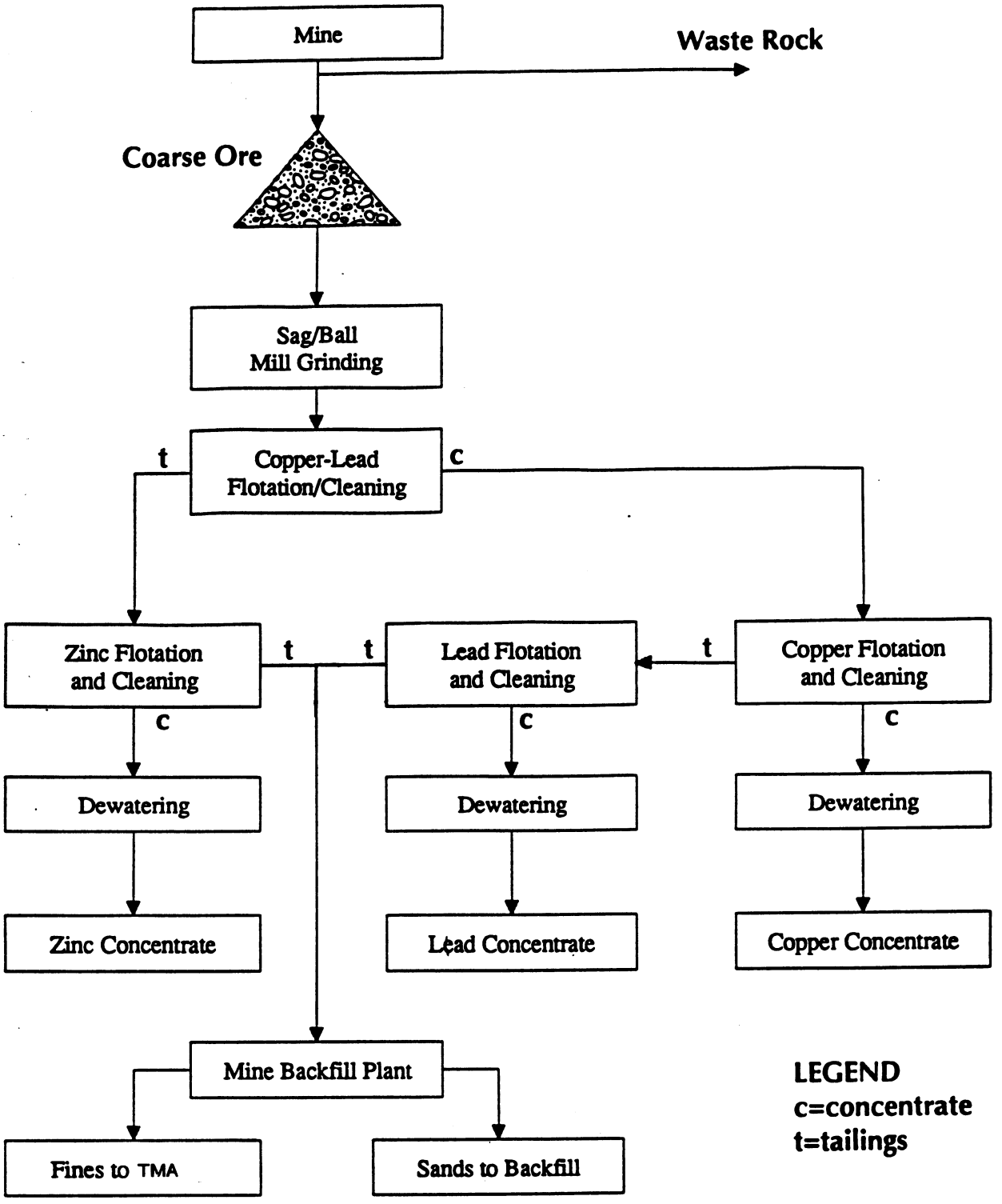
FIGURE 2-9

MINE DRAINAGE SCHEMATIC

Scale:	NOT TO SCALE	Date:	MARCH, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

c:\cadwork\3c49m5.dgn

93C049



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	APR.'95
APPROVED BY:	PAE	DATE:	APR.'95
APPROVED BY:	GWS	DATE:	APR.'95

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FIGURE 2-10
CONCENTRATOR PROCESS FLOWSHEET

Scale:	NOT TO SCALE	Date:	MARCH, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/dl/users/jpr1/3c49m5.dgn

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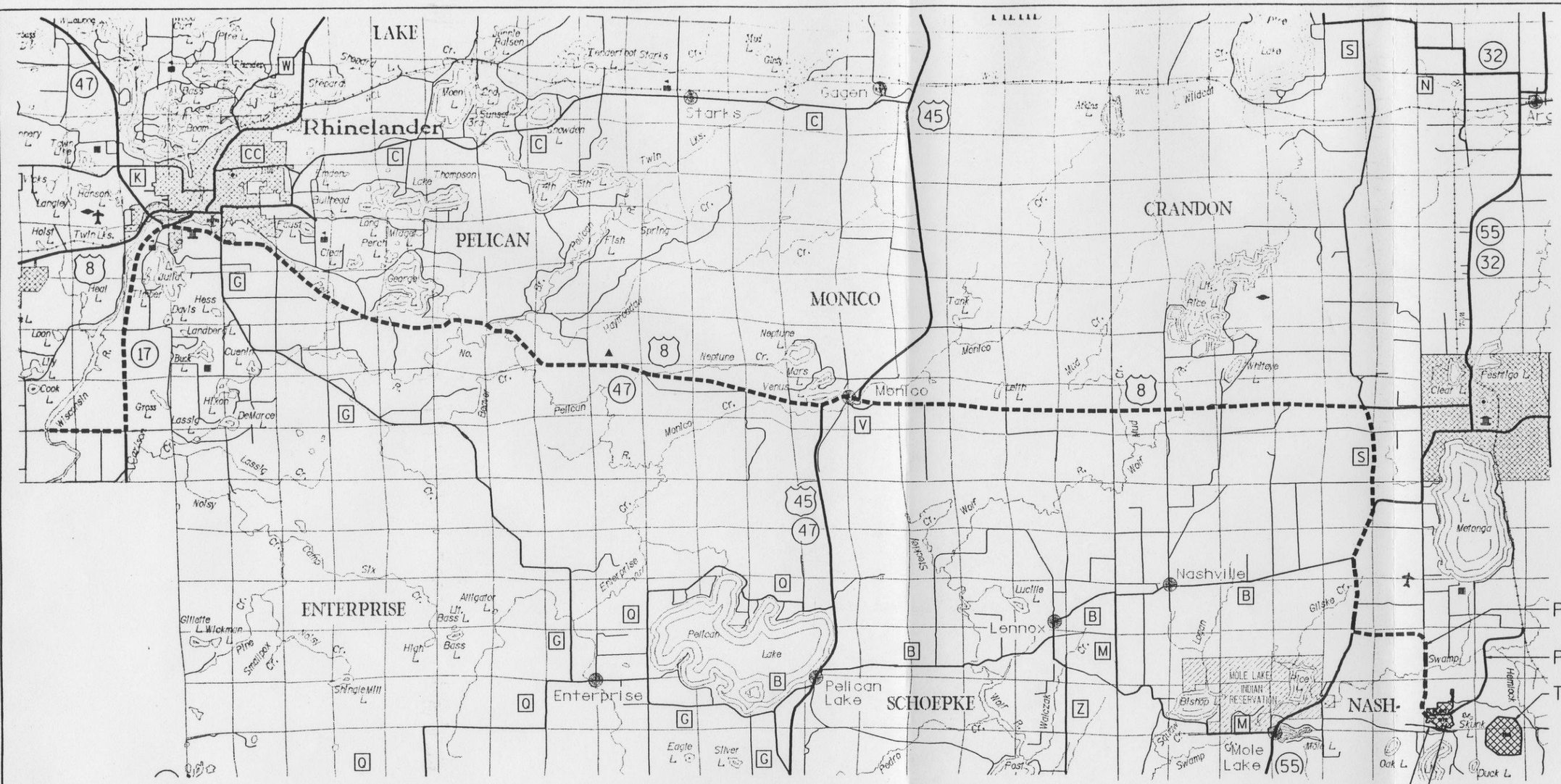

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HIGHWAY LETTER
- PROPOSED WASTEWATER PIPELINE

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY.'95
APPROVED BY:	PAE	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 2-11

PROPOSED PIPELINE ROUTE FOR WISCONSIN RIVER DISCHARGE

Scale: 0 6000' 12,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: GAM

c:\cadwork\4c65f7.dgn

93C049

2,283,000 E

2,285,000 E

2,287,000 E

117,000 N

115,000 N

113,000 N

A'

A

SEE FIGURE 2-12 FOR TYPICAL SECTION THRU TMA

APPROXIMATE LIMITS OF DISTURBANCE

PROPOSED LEACHATE FORCEMAIN

PROPOSED PERFORATED LEACHATE COLLECTION PIPE

PROPOSED CLEANOUT

PROPOSED RECLAIM PIPE

PROPOSED SUMP

PROPOSED SIDE SLOPE RISER

PROPOSED DECANT STRUCTURE

TMA 1

TMA 2

TMA 3

TMA 4

BIRCH LN

DUCK LAKE

1654.0 1650 1625 1631.0 1647.0 1643.0 1672.8 1673.0 1707.0 1689.0 1683.0 1685.5 1683.0 1718.0 1719.0 1726.5 1770.5 1578.5 1614.0 1614.0

1675 1700 1725 1600 1625 1650 1675 1700 1700 1675 1650

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- —1675— EXISTING CONTOUR
- 1692.0 SPOT ELEVATION
- SECTION LINE
- TMA APPROXIMATE LIMITS OF DISTURBANCE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

SCALE
0 300' 600'

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY.'95
APPROVED BY:	PAE	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 2-12

PROPOSED TMA LAYOUT

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	MRS

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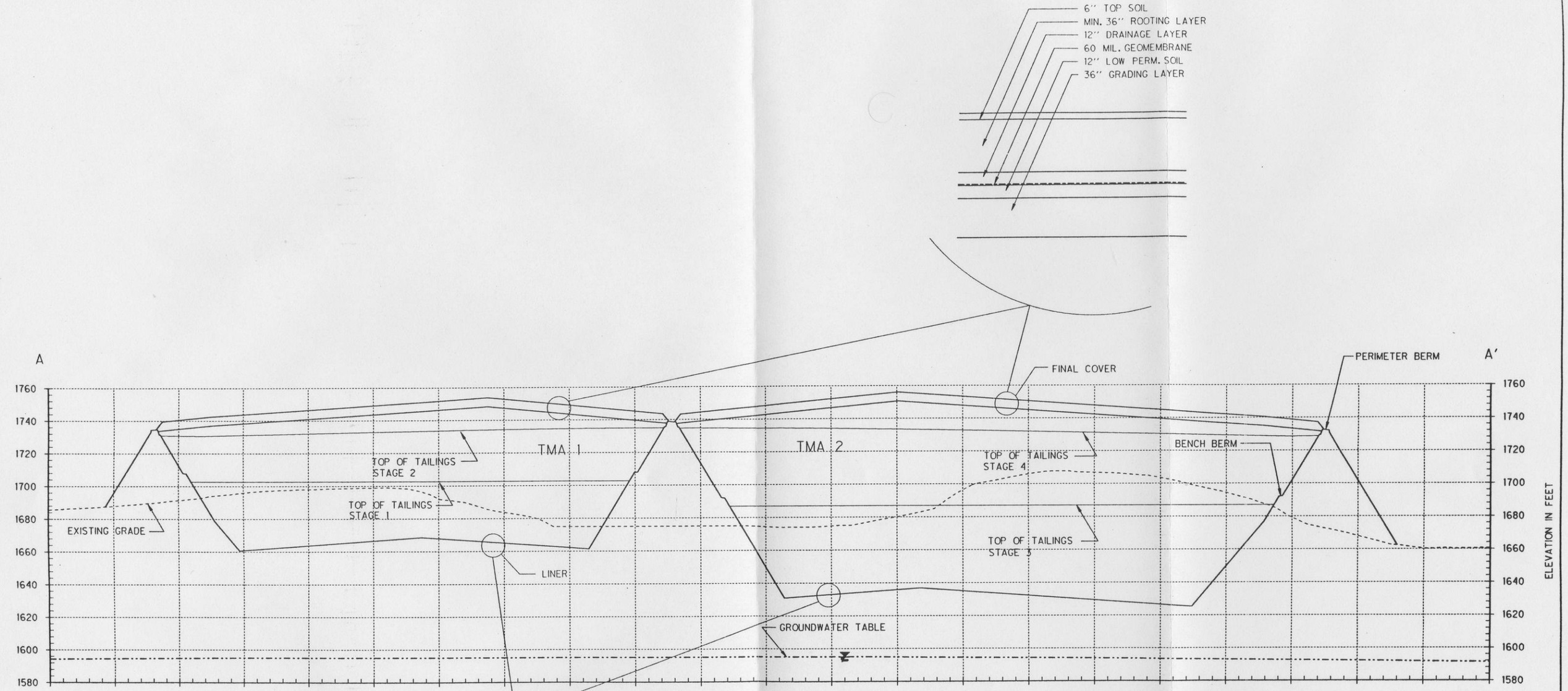
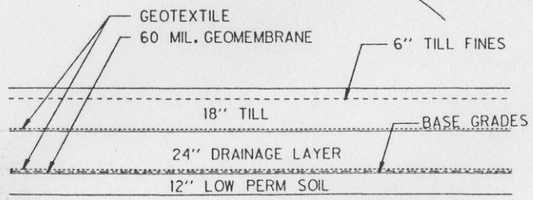
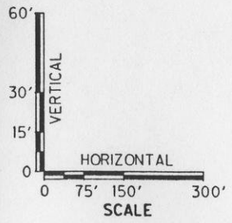


NOTE: VERTICAL SCALE IS EXAGGERATED

TYPICAL CROSS SECTION A-A' THROUGH TMA

NOT TO SCALE





TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	PAE	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 2-13
TYPICAL CROSS SECTION THROUGH TMA

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	MRS

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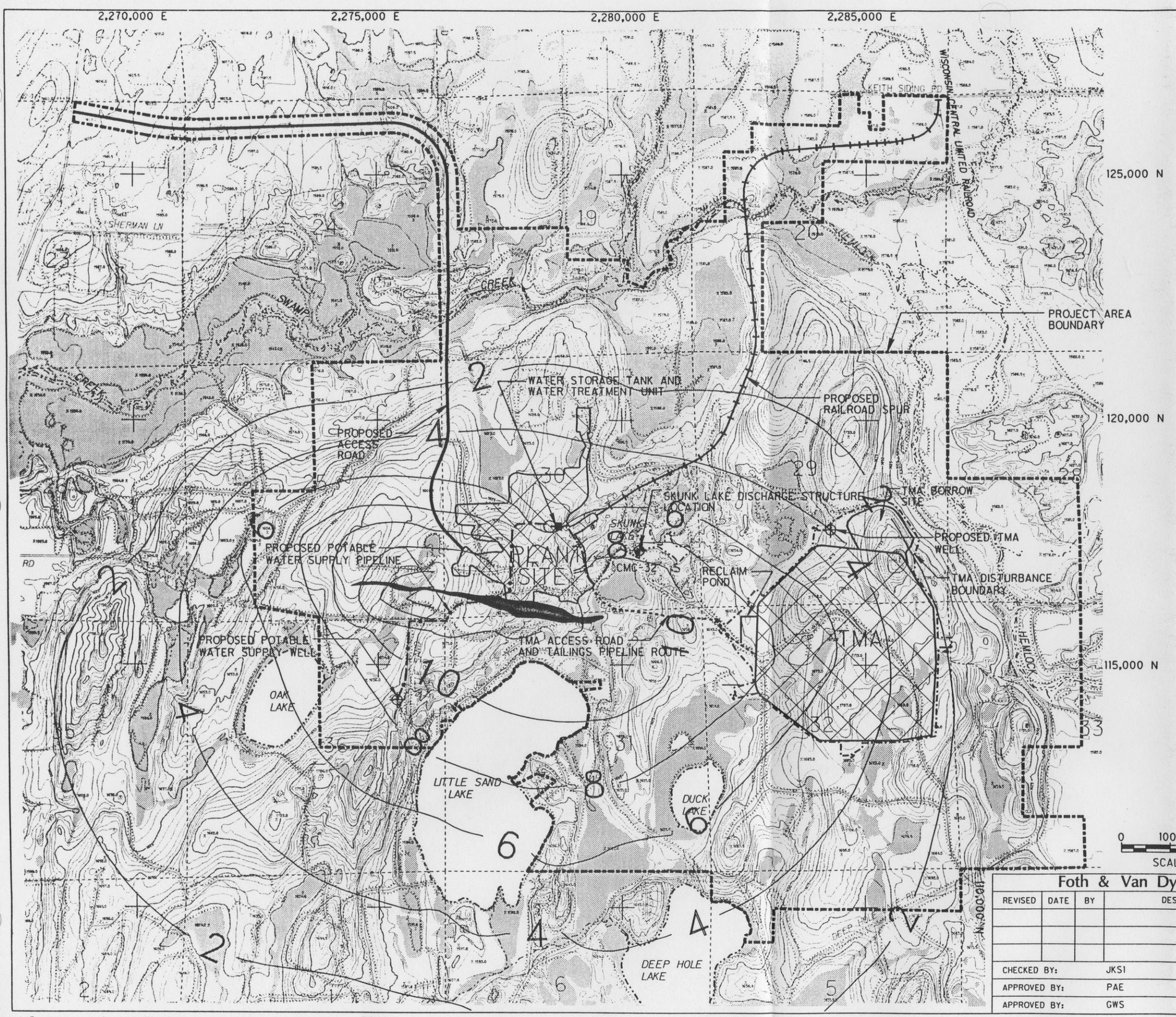

LEGEND

- LAKES
- STREAMS
- WETLANDS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 x — EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- ■ WATER TREATMENT UNIT
- CMC-32 — PROPOSED SKUNK LAKE MONITORING WELL
- PROPOSED POTABLE WATER SUPPLY WELL
- SKUNK LAKE MITIGATION PIPELINE ROUTE
- —2— BEST ENGINEERING JUDGMENT DRAWDOWN CONTOUR

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
6. DRAWDOWN CONTOURS GREATER THAN 20' HAVE BEEN DELETED FOR THIS DRAWING.

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REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 3-1
REGIONAL DRAWDOWN CONTOURS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/d1/users/jpr1/4c62z19.dgn

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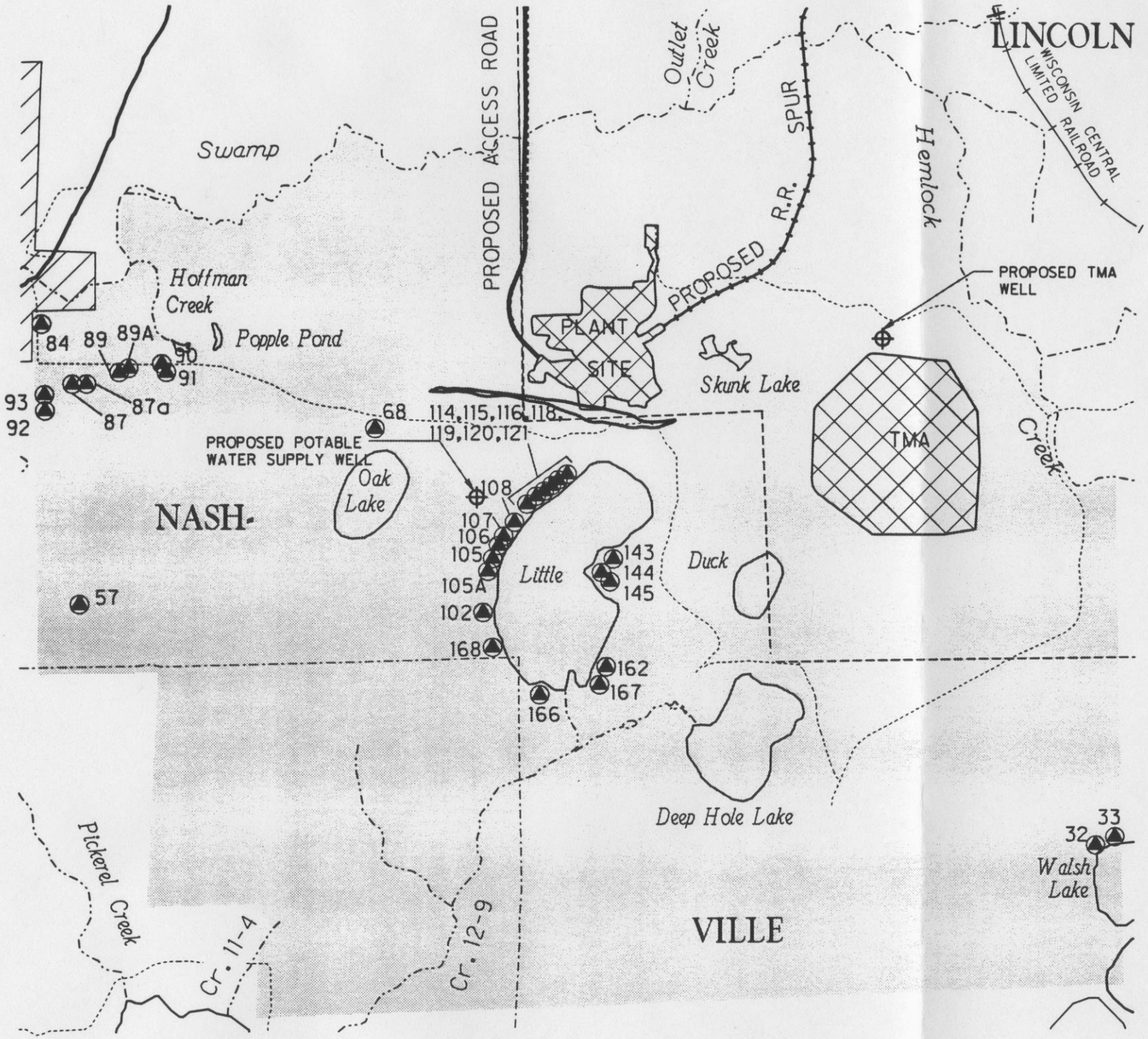

N

LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- (47) STATE HWY NO.
- [W] COUNTY HWY LETTER
- SURVEY AREA
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- 68 DOMESTIC WELL NUMBER AND LOCATION
- PROPOSED WATER SUPPLY WELL

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 3-2
DOMESTIC WATER WELL
LOCATION MAP

Scale: 0 1500' 3000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JOW

93C049

/d3/dl/users/jpcl/4c62z20.dgn

PLANT SITE

25 30 29 32 31 36 1 6 5

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED FACILITIES
- CMC PROPERTIES
- 143 DOMESTIC WATER WELL NUMBER AND LOCATION

OAK LAKE

68

PUBLIC ACCESS

134 135 136 137 138 139 140 141

YEAGER 119 120 116 118 119 111

121 MANTEY

DIETZLER

PALLEN

BETTERS

DIX

WALENTOWSKI

ROBERT KELCHNER

HAROLD PRYOR

WILLIAM BECKER

108 BECKER

107 FRISTSCHE

106 HAFERMAN

105 KELCHNER

105A 104 103 SEAWELL

WEBB 102

PIERTZ

168 KLOEHN

LITTLE SAND LAKE

PARKER 143

LUEWSKI 144

SCHALLOCK

SCHALLOCK

VERLOTTA 145

DUCK LAKE

SAND LAKE RD

FOREST COUNTY

LANGLADE COUNTY

MIHALKO, et. al.

162 G. JOHNSON

ARCHIE JOHNSON

167 G. BUCKLEY

G. BUCKLEY

L. DILLEY

166

MAUREEN NOTEBOOM

PHUEY

DEEP HOLE LAKE

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

	DATE	BY	DESCRIPTION
1	10-6-95	GWS	ADDED CMC PROPERTIES

REVISED

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	SVD1	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 3-3

LITTLE SAND LAKE
DOMESTIC WATER WELLS

Scale: 0 400' 800' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JOW

/d3/dl/users/jpr1/3c49f155.dgn

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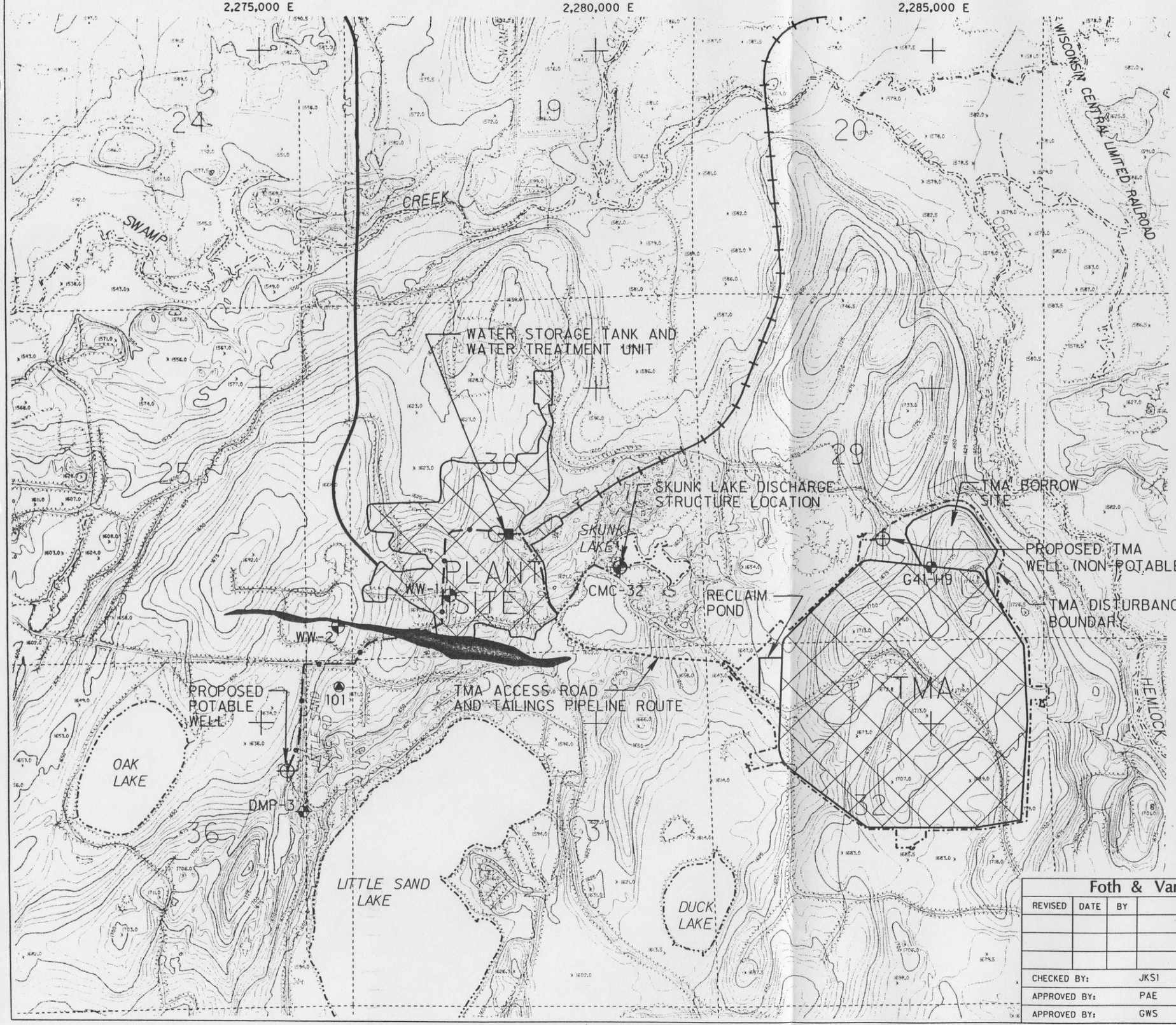

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- x 1692.0 — EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- CMC-32 — PROPOSED SKUNK LAKE MONITORING WELL
- WW-1 — CMC OWNED WELL
- PROPOSED POTABLE AND NON-POTABLE WATER SUPPLY WELLS
- 101 — CMC OWNED DOMESTIC WELL NUMBER AND LOCATION
- G41-H9 — MONITORING WELL BORING
- SKUNK LAKE MITIGATION PIPELINE ROUTE
- PROPOSED POTABLE WATER SUPPLY PIPELINE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 750' 1500'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 3-4
EXISTING AND PROPOSED
CMC WATER SUPPLY WELLS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/d1/users/jpr1/4c62z18.dgn

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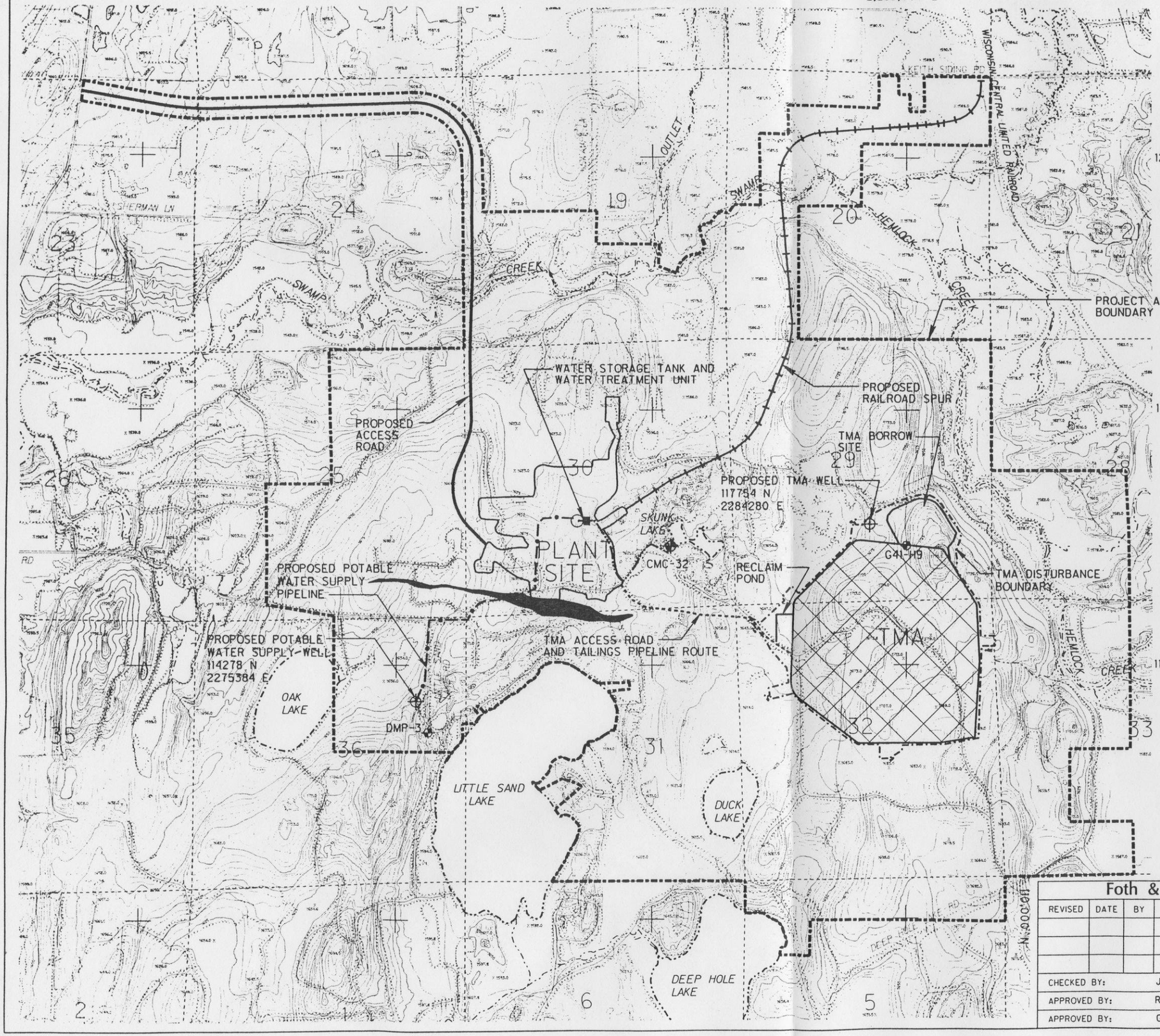


LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- 1692.0 — EXISTING SPOT ELEVATION
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- CMC-32 — PROPOSED SKUNK LAKE MONITORING WELL
- PROPOSED POTABLE WATER SUPPLY WELL
- G41-H9 — MONITORING WELL BORING
- PROPOSED POTABLE WATER SUPPLY PIPELINE
- SKUNK LAKE MITIGATION PIPELINE ROUTE

N

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 25 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

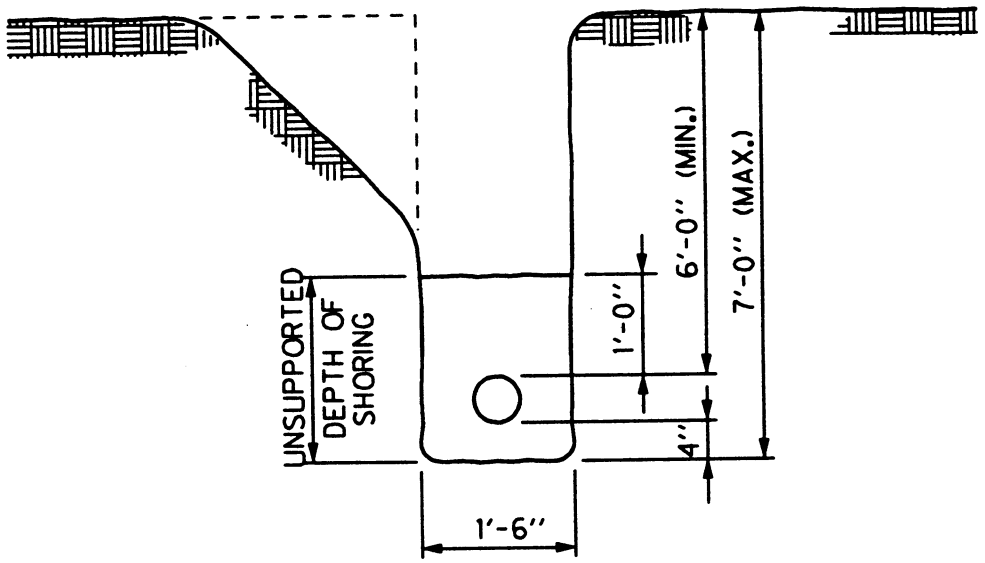
CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 3-5
PROPOSED WELL LOCATION MAP

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB

93C049



TYPICAL PIPE TRENCH

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:	JKSI			DATE: SEPT.'95
APPROVED BY:	PAE			DATE: SEPT.'95
APPROVED BY:	GWS			DATE: SEPT.'95

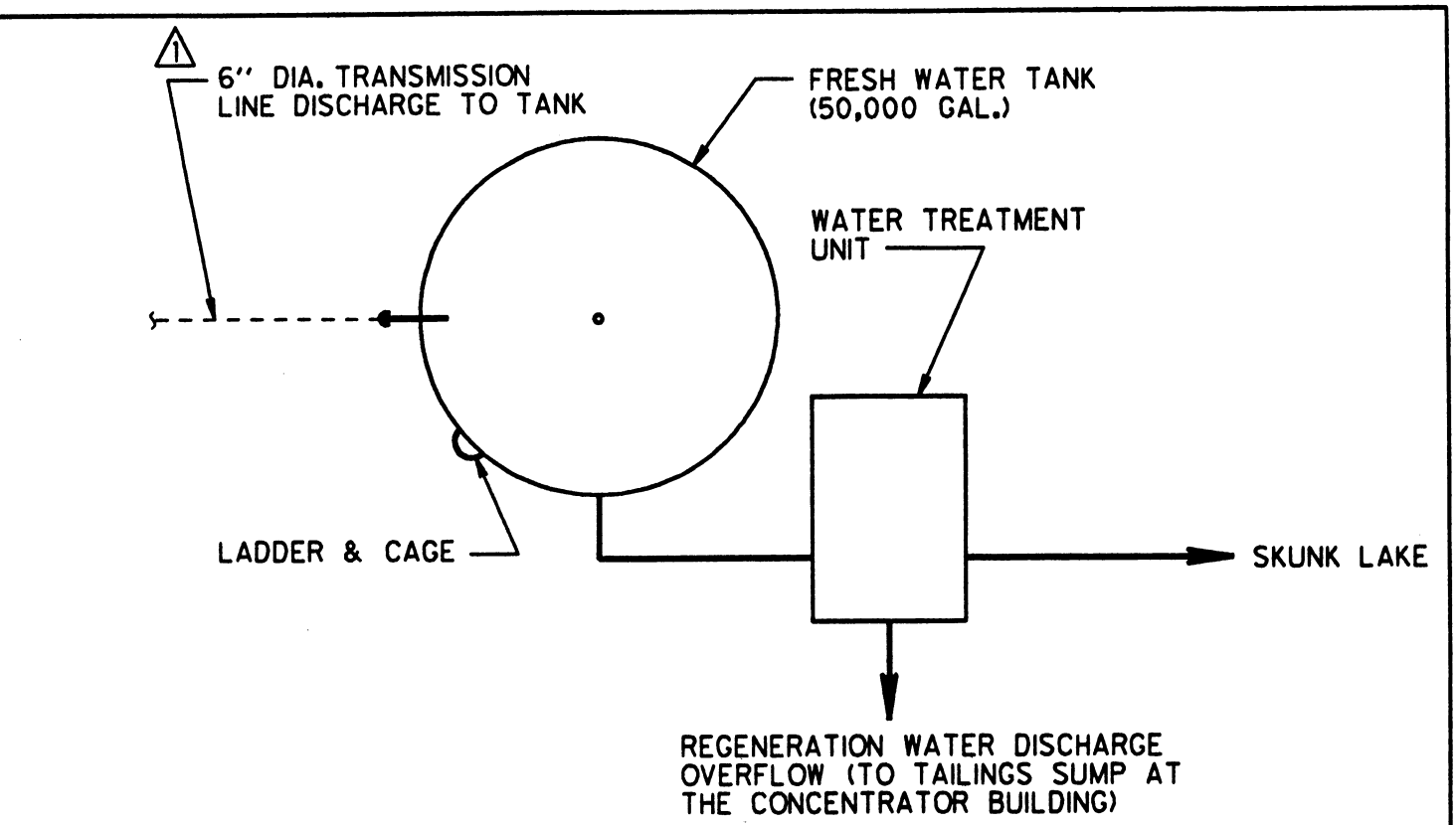
Crandon Mining Company

FIGURE 3-6
TYPICAL PIPE TRENCH

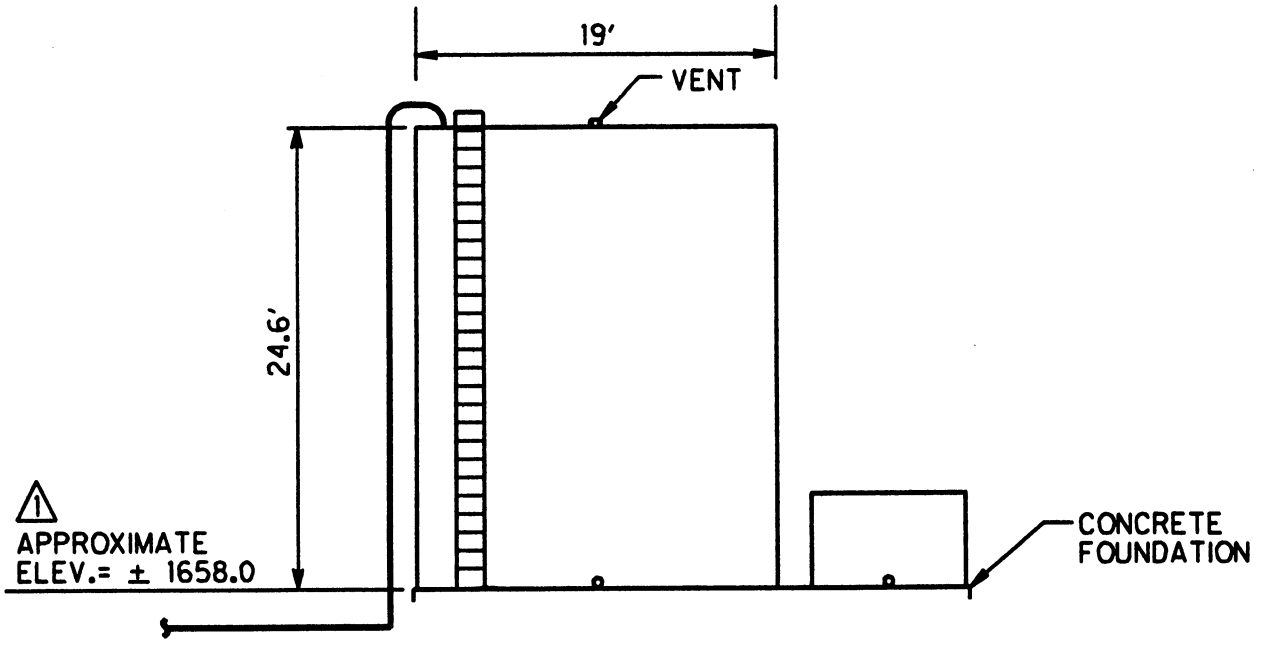
Scale:	N.T.S.	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

93C049

/d3/dl/users/jpr1/4c62f56.dgn



PLAN VIEW



ELEVATION LOOKING NORTH

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	11/14/95	PAE	PIPE DIA. AND GROUND ELEVATION

CHECKED BY:	JKSI	DATE: SEPT. '95
APPROVED BY:	PAE	DATE: SEPT. '95
APPROVED BY:	GWS	DATE: SEPT. '95

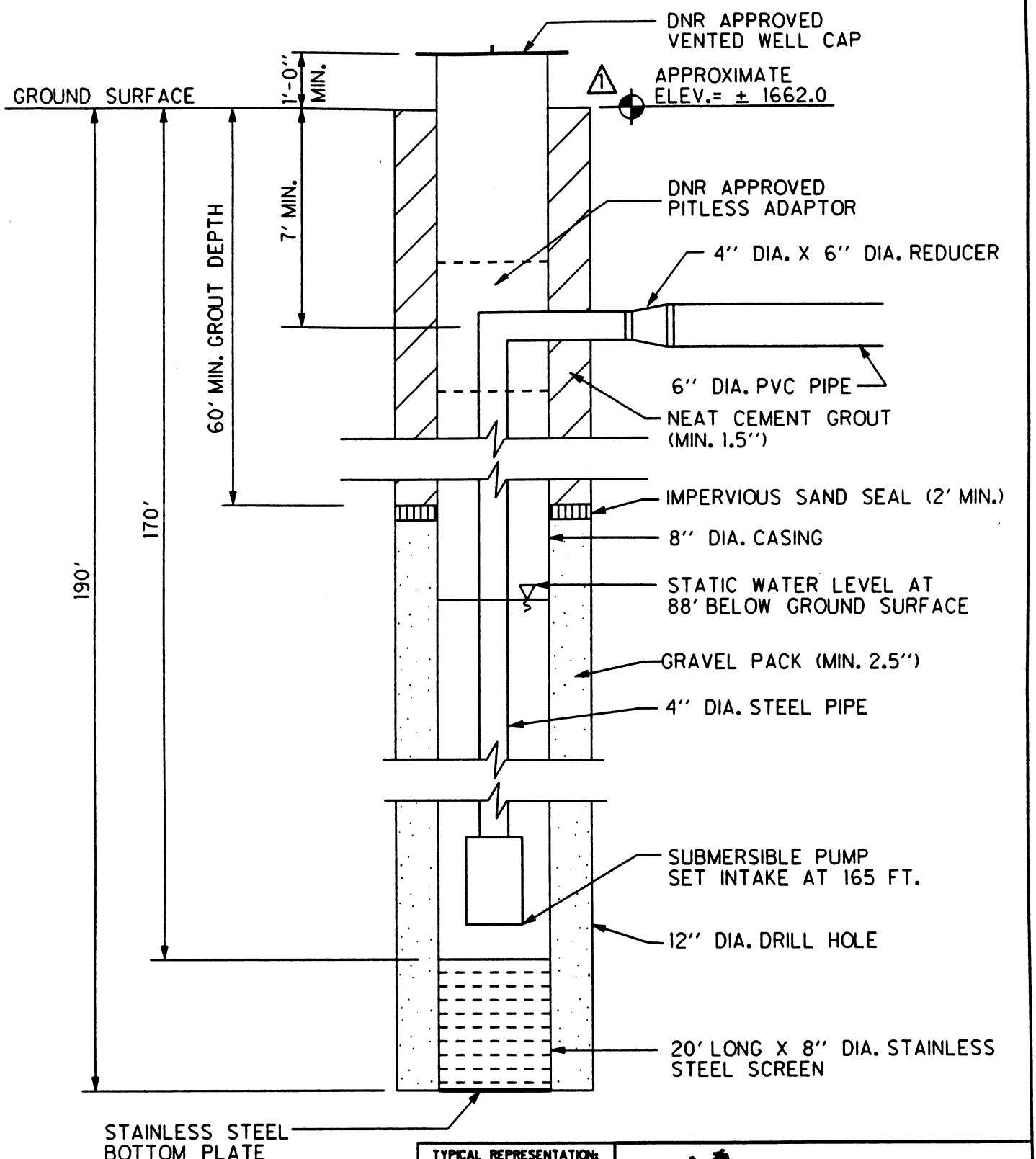
Crandon Mining Company

FIGURE 3-7
WATER STORAGE TANK AND WATER TREATMENT UNIT

Scale:	N.T.S.	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

C:\cadwork\4C62F57.dgn

93C049



TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	11/14/95	PAE	WELL CONSTRUCTION AND GROUND ELEV. REVISION

CHECKED BY:	JKSI	DATE: SEPT. '95
APPROVED BY:	PAE	DATE: SEPT. '95
APPROVED BY:	GWS	DATE: SEPT. '95

Crandon Mining Company

FIGURE 3-8

PROPOSED POTABLE
WELL CONSTRUCTION

Scale:	N.T.S.	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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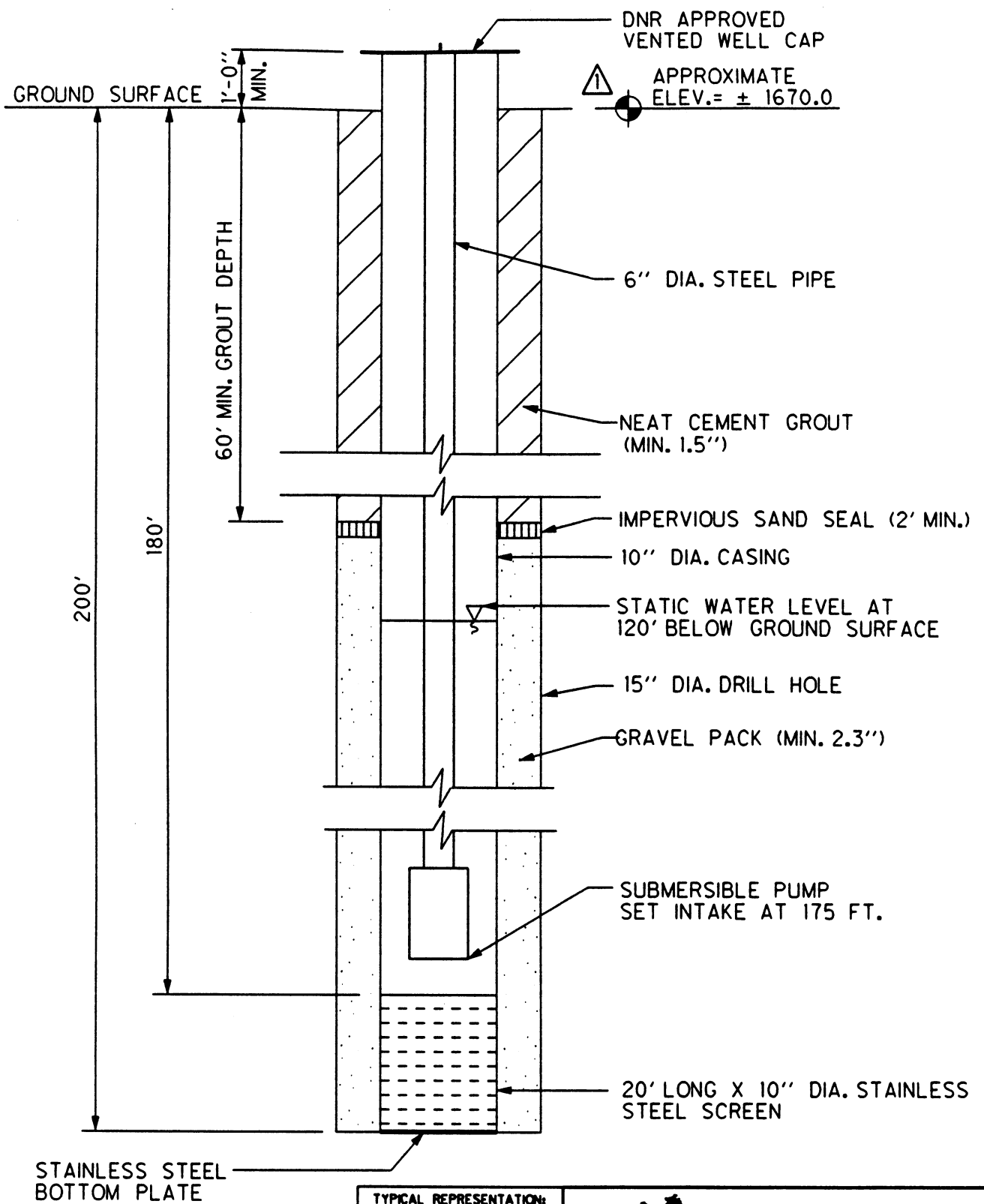
93C049



TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	11/14/95	PAE	WELL CONSTRUCTION AND GROUND ELEV. REVISION

CHECKED BY:	JKSI	DATE: SEPT. '95
APPROVED BY:	PAE	DATE: SEPT. '95
APPROVED BY:	GWS	DATE: SEPT. '95

Crandon Mining Company

FIGURE 3-9

PROPOSED TMA
WELL CONSTRUCTION

Scale:	N.T.S.	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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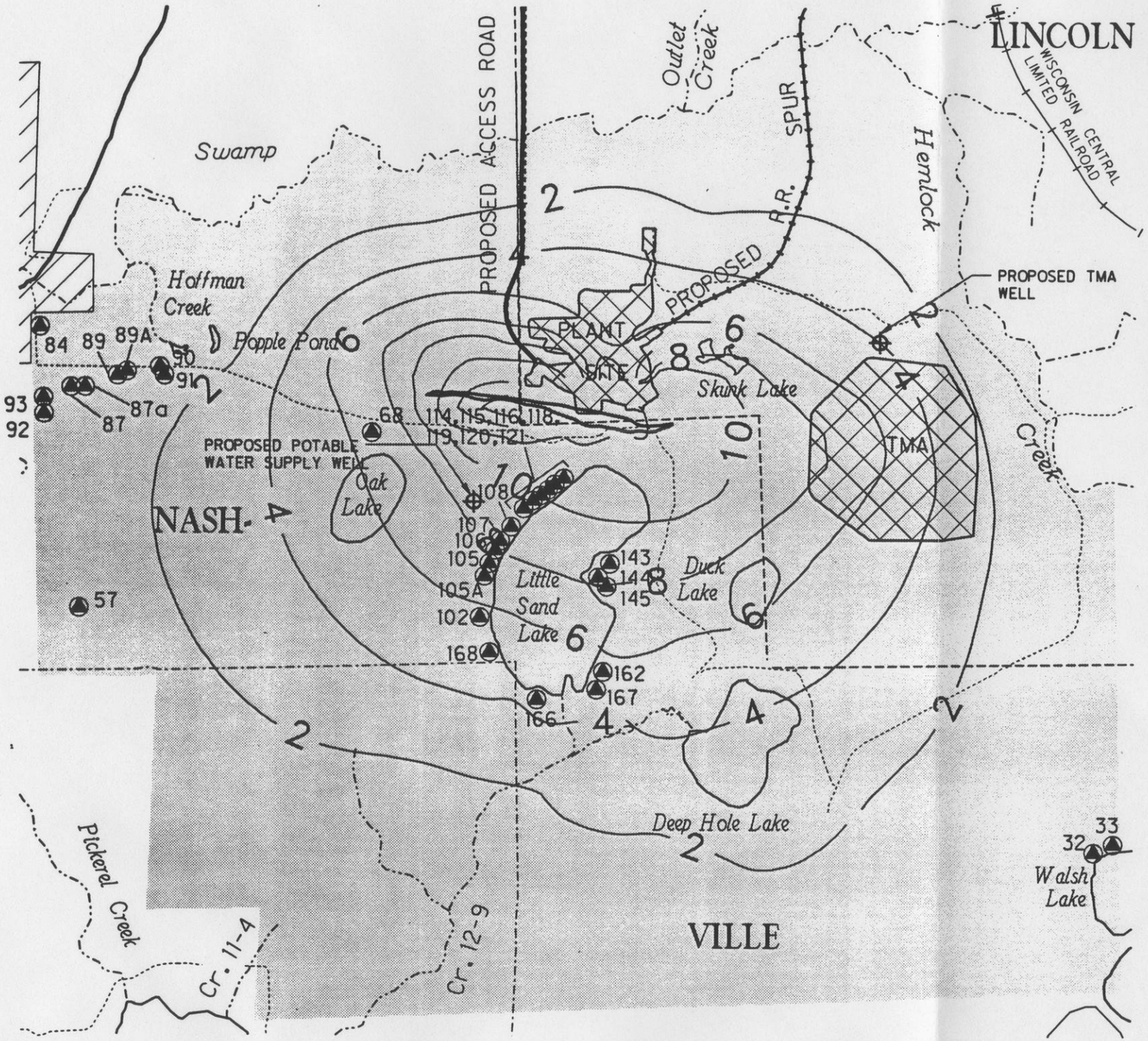
93C049



NOTE:
DRAWDOWN CONTOURS GREATER THAN 20' HAVE BEEN DELETED FOR THIS DRAWING.

N

LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- (47) STATE HWY NO.
- [W] COUNTY HWY LETTER
- SURVEY AREA
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- 68 DOMESTIC WELL NUMBER AND LOCATION
- PROPOSED WATER SUPPLY WELL
- —2— BEST ENGINEERING JUDGMENT DRAWDOWN CONTOUR

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:		JKSI	DATE: SEPT.'95	
APPROVED BY:		PAE	DATE: SEPT.'95	
APPROVED BY:		GWS	DATE: SEPT.'95	

Crandon Mining Company

FIGURE 3-10
MAXIMUM EXTENT OF DRAWDOWN IN RELATION TO PRIVATE WELLS

Scale: 0 1500' 3000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JOW

/d3/dl/users/jpr1/4c62z16.dgn

93C049

Appendix A

Boring Logs

Appendix A-1	Boring Log DMP-3
Appendix A-2	Boring Log G41-H9

Appendix A-1

Boring Log DMP-3

BORING DMP-3

SURFACE ELEVATION 1623.55

COORDINATES N 113,665 E 2,275,625

DEPTH (FEET)	OTHER TESTS	SHEAR STRENGTH PSF	ATTERBERG LIMITS: LIQUID LIMIT %	ATTERBERG LIMITS: PLASTIC LIMIT %	ATTERBERG LIMITS: PLASTICITY INDEX %	FIELD MOISTURE CONTENT %	DRY DENSITY PCF	PERCENT RECOVERED	R&D
0									
5	SA, PA					4.2			
10									
15									
20									
25									
30	SA					6.3			
35									
40									
45									
50									
55	SA					14.7			
60									
65	SA, PA					8.4			
70									

BLOW COUNTS / SAMPLES	SYMBOLS	DESCRIPTIONS	ELEVATION (FEET)
51/9"	OL	BLACK ORGANIC SILTY CLAY WITH SOME SAND AND ROCK FRAGMENTS. (SOFT)	
	SM	YELLOWISH-BROWN SILTY FINE TO MEDIUM SAND WITH SOME FINE TO COARSE GRAVEL. (VERY DENSE)	1620
81			
		GRADES WITH ROCK FRAGMENTS	1615
54/9"			
			1610
64			
			1605
55/2"			
		GRADES MORE FINE TO COARSE GRAVEL	1600
200/3"			
			1595
200			
			1590
250/3"			
	SP	YELLOWISH-BROWN FINE TO MEDIUM SAND WITH TRACE COARSE SAND AND OCCASIONAL FINE GRAVEL. (VERY DENSE)	1585
230/7"			
			1580
1-10-80 ▽ 44.2'			
306/3"			
		GRADES LESS COARSE SAND AND FINE GRAVEL	1575
200/6"			
		GRADES BROWN WITH MULTICOLORED FINE TO COARSE GRAVEL	1570
166/10"			
	SC	DARK YELLOWISH-BROWN SILTY AND CLAYEY FINE TO MEDIUM SAND WITH SOME FINE TO MEDIUM GRAVEL. (HARD)	1565
155/8"		GRADES WITH CLAY LAYERS, WITH ROCK FRAGMENTS AND FINE TO COARSE GRAVEL	
			1560
186/6"			

BORING COMPLETED AT A DEPTH OF OF 65.6 FEET ON 11-2-79.
SURFACE CASING USED TO A DEPTH OF 10.0 FEET.
PIEZOMETER INSTALLED ON 11-2-79.
2 INCH PVC SLOTTED FROM 57.5 TO 65.5 FEET.
GRAVEL PACK: 53.2 TO 65.6 FEET.
BENTONITE: 49.0 TO 53.2 FEET.
GROUT: 0.0 TO 49.0 FEET.
GROUND WATER LEVEL RECORDED AT 44.2 FEET ON 1-10-80.

EXXON MINERALS COMPANY, U.S.A.
CRANDON PROJECT

LOG OF BORING DMP-3
SHEET 1 OF 1

DAMES & MOORE | FIGURE B-88

Appendix A-2

Boring Log G41-H9

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 1 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT	GROUNDWATER OBSERVATION WELL
0.0				-	1	DO	Hydraulic Push	12/24	
		Compact to very dense, brown, fine to coarse SAND, some fine to coarse gravel, some silt, occasional cobbles	SM	-	2	DO	Hydraulic Push	12/24	
				-	3	DO	Air Hammer	18/18	
7.92									
26.0		Very dense, brown, fine to coarse SAND, trace fine to coarse gravel, trace to some silt to fine to coarse gravelly fine to coarse SAND, trace silt	SP-SM	-	4	DO	Air Hammer	18/18	
10.4									
34.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 2 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT. PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
		CONTINUED							
10.4 / 34.0									
				-	5	DO	Air Hammer	12/12	
		Very dense, brown, fine to coarse SAND, trace fine to coarse gravel, trace to some silt to fine to coarse gravelly fine to coarse SAND, trace silt	SP-SM						
					6	DO	Air Hammer	8/8	
16.76 / 55.0									
		Very dense, brown, silty fine to coarse SAND, some fine to coarse gravel to fine to coarse gravelly fine to coarse SAND, some silt, occasional cobbles	SM	-	7	DO	Air Hammer	16/16	
20.3 / 66.5									
		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 3 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: HAMMER BLOWS PER 6IN.	SAMPLES: REC / ATT.	GROUNDWATER OBSERVATION WELL
		CONTINUED							
20.3 / 66.5									
				-	8	DO	Air Hammer	21/21	
		Very dense, brown, silty fine to coarse SAND, some fine to coarse gravel to fine to coarse gravelly fine to coarse SAND, some silt, occasional cobbles	SM						
				-	9	DO	Air Hammer	24/24	
25.91 / 85.0									
		Very dense, multi-colored, fine to coarse sandy fine to coarse GRAVEL, trace silt	GP	-	10	DO	Air Hammer	12/12	
28.96 / 95.0									
		Very dense, brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP to SM						
30.18 / 99.0									
		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
30.18 / 99.0		CONTINUED							
				-	11	DO	Air Hammer	24/24	
		Very dense, brown, fine to coarse SAND, some fine to coarse gravel, trace to some silt	SP to SM						▼ 5/26/81 33.69 / 110.5
				-	12	DO	Air Hammer	24/24	
35.05 / 115.0									
		Very dense, gray-brown to red-brown, silty, fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly fine to coarse SAND, some silt, frequent cobbles and occasional boulders	SM	-	13	DO	Air Hammer	24/24	
				-	14	DO	Air Hammer	16/16	
40.08 / 131.5		CONTINUED							

Job No. 736085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)
SURFACE ELEV. 1702.0 ft. (518.78m)
DATUM USGS MSL
DRILL RIG Schramm Rotadrill T64HP

BORING LOG G41-H9

SHEET 5 OF 10
PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM
DATE STARTED 5/14/81 DATE COMPLETED 5/26/81
DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
40.08 / 131.5		CONTINUED							
		Very dense, gray-brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly fine to coarse SAND, some silt, frequent cobbles and occasional boulders	SM	-	15	DO	Air Hammer	6/18	
				-	16	DO	Air Hammer	15/15	
				-	17	DO	Air Hammer	7/7	
50.75 / 166.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)
SURFACE ELEV. 1702.0 ft. (518.78m)
DATUM USGS MSL
DRILL RIG Schramm Rotadrill T64HP

BORING LOG G41-H9

PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM
DATE STARTED 5/14/81 DATE COMPLETED 5/26/81
DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC / ATT.	GROUNDWATER OBSERVATION WELL
50.75 / 166.5		CONTINUED							
				-	18	DO	Air Hammer	6/6	
		Very dense, gray-brown to red-brown, silty fine to coarse SAND, some fine to coarse gravel, trace clay to fine to coarse gravelly fine to coarse SAND, some silt, frequent cobbles and occasional boulders	SM	-	19	DO	Air Hammer	12/12	
				-	20	DO	Air Hammer	12/12	
59.42 / 195.0		Very dense, orange-brown, fine to medium SAND, trace silt	SP-SM	-	21	DO	Air Hammer	9/9	2" Solid PVC Pipe (to surface) Grout (to surface)
61.42 / 201.5		CONTINUED							CONTINUED

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 7 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: HAMMER BLOWS PER 6 IN.	SAMPLES: REC / ATT.	GROUNDWATER OBSERVATION WELL
61.42		CONTINUED							CONTINUED
201.5		Very dense, orange-brown, fine to medium SAND, trace silt	SP-SM						Grout
62.48									63.03 / 207.0
205.0		Very dense, red-brown, silty fine to coarse SAND, some fine to coarse gravel	SM						Bentonite Clay Seal
				-	22	DO	Air Hammer	11/11	64.01 / 210.0
65.53									2" Solid PVC Pipe
215.0									Pea Gravel
				-	23	DO	Air Hammer	18/18	
		Very dense, brown to red-brown, fine to coarse SAND, trace silt to fine to coarse SAND, some fine to coarse gravel, trace silt	SP						
				-	24	DO	Air Hammer	18/18	70.10 / 230.0
72.09									2" Slotted PVC Pipe
236.5		CONTINUED							Pea Gravel (to bottom of boring)
									CONTINUED

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC / ATT.	GROUNDWATER OBSERVATION WELL
72.09 / 236.5		CONTINUED							CONTINUED
		Very dense, brown to red-brown, fine to coarse SAND, trace silt to fine to coarse SAND, some fine to coarse gravel, trace silt	SP	-	25	DO	Air Hammer	18/18	Pea Gravel 73.15 / 240.0 Pea Gravel (to bottom of boring)
74.67 / 245.0				-	26	DO	Air Hammer	18/18	
		Very dense, brown, fine to coarse SAND, trace fine to coarse gravel, trace silt	SP-SM	-	27	DO	Air Hammer	18/18	
80.77 / 265.0		Very dense to hard, dark brown to red-brown, fine sandy SILT, trace clay to silty fine SAND (very poorly graded, some stratification evident)	SM to ML	-	28	DO	Air Hammer	18/18	
82.75 / 271.5		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 9 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
82.75		CONTINUED							
271.5									
				-	29	DO	Air Hammer	18/18	
		Very dense to hard, dark brown to red-brown, fine sandy SILT, trace clay to silty fine SAND (very poorly graded, some stratification evident)	SM to ML						
				-	30	DO	Air Hammer	18/18	
89.92									
295.0									
		Very dense, brown, fine to coarse gravelly fine to coarse SAND, some silt	SM						
				-	31	DO	Air Hammer	18/18	
92.66									
304.0		CONTINUED							

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

COOR. N117330 ft. (N35762m)
E2285000 ft. (E696469m)

BORING LOG G41-H9

SHEET 10 OF 10

SURFACE ELEV. 1702.0 ft. (518.78m) PROJECT EXXON CRANDON TAILINGS DISPOSAL SYSTEM

DATUM USGS MSL DATE STARTED 5/14/81 DATE COMPLETED 5/26/81

DRILL RIG Schramm Rotadrill T64HP DRILLING METHOD Mud Rotary

DEPTH METER / FEET	STRAT PLOT	DESCRIPTION	UNIFIED CLASS	BLOWS / FOOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES HAMMER BLOWS PER 6 IN.	SAMPLES REC./ATT.	GROUNDWATER OBSERVATION WELL
92.66 / 304.0		CONTINUED							
		Very dense, brown, fine to coarse gravelly fine to coarse SAND, some silt	SM						
94.64 / 310.5		Weathered to sound, green, metavolcanic TUFF		-	32	Cuttings			
96.01 / 315.0		END OF BORING							

NOTES

1. Elevation of top of protector pipe, 1704.8 ft. (519.63m).

Table of Water Level Readings by Date. Readings Indicate Depth Below Ground Surface.

DATE	5/26/81	6/10/81					
DEPTH (m)	33.69	33.67					
DEPTH (ft.)	110.5	110.5					

Job No. 786085
Scale 1" = 5'

Golder Associates

Drawn SKB
Checked MRB

Appendix B

Well Specifications

Appendix B-1	General Provisions for Constructing Water Wells
Appendix B-2	Well Performance Testing
Appendix B-3	Gravel Pack Well

Appendix B-1

General Provisions for Constructing Water Wells

GENERAL PROVISIONS FOR CONSTRUCTING WATER WELLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section contains general provisions applying to the construction of water wells.

B. Work under this contract consists of furnishing all materials, labor, equipment, shipping and storage necessary to construct the well with all appurtenances and shall include:
1. Drilling.
2. Casing installation.
3. Grouting.
4. Testing and sampling.
5. Site and groundwater protection.
6. Disinfection.
7. Well abandonment.
8. Safety and related matters.
9. Clean-up.

1.2 REFERENCE STANDARDS

A. American Water Works Association (AWWA):
1. AWWA A-100 Standard for Deep Wells
2. AWWA B-300 Standard for Hypochlorites
3. AWWA C-654 Standard for Disinfection of Wells

B. American Standard for Testing and Materials (ASTM):
1. ASTM A53 Specifications for Steel Pipe
2. ASTM A106 Specification for Seamless Carbon Steel Pipe for High-Temperature Service
3. ASTM A589 Specification for Seamless and Welded Carbon Steel Well Water Pipe
4. ASTM C150 Specifications for Portland Cement

1.3 QUALITY ASSURANCE

A. The work shall be performed by an experienced well driller licensed in the state in which the well is to be located.

B. If requested furnish information and references on similar wells constructed.

1.4 SUBMITTALS

A. Samples
1. Formation Samples:
a. Take at five foot intervals and at changes in geologic formations.
b. Submit to the State Geological Survey in containers provided for that purpose.
2. Water samples for bacteriological analysis.
a. Two shall be taken during the course of the test pumping.
b. Provide analysis as required by the governing State authority.
c. If unsafe, disinfect and resample.
3. Water samples for other analysis.
a. To be taken by others.

B. Reports
1. Submit one copy of following to governing State agency:
a. Well constructor's report.
2. Submit one copy of following to Owner's representative:
a. Well constructor's report.
b. Pump test report on approved form.
c. Plumbness and alignment report.
d. Driller's log including data on construction progress, formations, water levels, and sampling.

C. Materials Documentation:
1. Grout:
a. Furnish certificate from supplier attesting to:
1) Design mix.
2) Water cement ratio.
3) Type of cement.
4) Admixtures and quantity added.

1.5 JOB CONDITIONS

A. Test Well Data
1. Data on test well is included in these documents.

PART 2 - PRODUCT

2.1 CASING AND LINERS

A. Protective casing shall be new prime steel pipe meeting one of the following standards.
1. ASTM A53
2. ASTM A106
3. ASTM A589:
a. Type I, Grade A or B
b. Type II, Grade A

B. The protective casing shall have the following minimum weights and thicknesses.

Size (Inches) External	Diameter (Inches) Internal	Thickness (Inches)	Plain Ends (Pounds/Foot)
6	6.625	6.065	0.280	18.97
8	8.625	7.981	0.322	28.55
10	10.750	10.020	0.365	40.48
12	12.750	12.000	0.375	49.56
14	14.000	13.250	0.375	54.57
16	16.000	15.250	0.375	62.58
18	18.000	17.250	0.375	70.59
20	20.000	19.250	0.375	78.60
24	24.000	23.000	0.500	125.49

2.2 CEMENT GROUT

A. All cement shall be ASTM C150.

B. Neat Cement Grout:
1. Not contain more than six gallons of water per sack (94 lbs.) of cement.
2. Additives shall not be used unless authorized in advance of time for grouting.

2.3 CHLORINE

A. Chlorine compounds shall meet AWWA B-300.

B. The following chlorine compounds are approved for use during well construction and for disinfection.
1. Calcium Hypochlorite (HTH).
2. Sodium Hypochlorite.

PART 3 - EXECUTION

3.1 GENERAL

A. Protect well and aquifer from following:
1. Contaminated water.
2. Oil, fuel, chemicals, and bacteria.
3. Tampering.

B. Perform work in a manner to avoid breakdown or caving-in of formations.

C. Unattended wells shall be capped at all times.

D. Completed wells shall have a steel plate tack welded to top of inner casing:
1. Tack at a minimum of four locations.
2. Overlap casing a minimum of 1/2 inches around the perimeter.

E. Aids and additives for drilling and development may be used only when authorized by Owner's representative.

F. Unacceptable Water Supply:
   1. In the event that water of acceptable quality cannot be obtained due to unforeseen contamination encountered through no fault of the Contractor and reasonable efforts to locate and remove source of contamination are unsuccessful, this contract shall be considered complete provided that all other provisions of specifications are met.

3.2 WELL CONSTRUCTION SITE

A. Protection of the Site
   1. Protect all structures, walks, pipelines, trees, shrubbery, lawns, etc. during the progress of his work.
   2. Remove drill cuttings, debris, and unused materials.
   3. Upon completion of work restore site to its original conditions.

B. Mud Pond and Storage Pond
   1. Provide a mud and waste pond and allow only clear water to overflow:
      a. Point of discharge shall be as approved by Owner's representative.
      b. Line pond to prevent seepage into ground.
   2. Provide a water storage pond and water supply when required.
   3. Ponds shall not be located on location of proposed building or utilities.
   4. Dispose of excess mud and wastes from ponds an approved site as required.
   5. Ponds shall be filled in upon completion of well construction in a manner approved by the Owner's representative.

3.3 WELL GROUTING

A. Notify and submit the proposed grouting method to Owner's representative 48 hours prior to the anticipated grouting time and notify the Governing Authority.

B. Grouting shall not proceed unless Owner's representative is at the site.

C. Place grout in one continuous operation with a grout pump.

D. Neat cement and sand cement grout shall be passed through a screen with openings which do not exceed one-half inch in size.

E. Grout shall be pumped in place through a steel tremie pipe placed to bottom of annular opening or grout shoe.

F. Pumping of grout shall continue until consistency of grout overflowing is equal to that being installed.

G. If grout settles, additional grout shall be added to refill annular opening.

H. Allow to set for 72 hours before continuing work.

I. Provide a container and scale to determine grout consistency.

3.4 CLEANING AND DISINFECTION

A. A chlorine residual of at least 10 parts per million shall be maintained in well throughout construction period.

B. Any water used in well construction shall contain a chlorine residual.

C. After well construction is completed, well shall be cleaned of oil, grease, and foreign materials.

D. Prior to test pumping the well shall be disinfected.
   1. A chlorine solution shall be added to the well so the concentration throughout is 50 to 100 parts per million the well.
   2. The casing and well above the water level shall be rinsed or brought into contact with the chlorinated water.
   3. Additional chlorinated water shall be added to the well to force the solution through the screen and into the formation.
   4. The chlorine solution shall remain in the well for a minimum of 12 hours.
   5. The Owner's representative shall be contacted for chlorination of flowing wells.

E. The test pump should be disinfected as it is installed in the well.

3.5 PLUMBNESS AND ALIGNMENT TESTING

A. Wells in unconsolidated formations which are less than 100 feet in depth are exempt from testing.

B. Final plumbness and alignment test shall be conducted in the presence of Owner's representative.

C. Plumbness and alignment shall be tested by lowering a 40 foot dummy to a depth greater than the lowest anticipated pump setting.
   1. Outer diameter of dummy shall not be more than 1/2" smaller than the diameter of casing or hole being tested.
   2. Dummy shall consist of a rigid spindel with three rings, each ring being 12" long.
      a. Rings shall be cylindrical and shall be fastened at the ends and center of spindel.

D. Tolerances
   1. Dummy shall move freely throughout the length of the casing or hole to the required depth.
   2. Well shall not vary from the vertical in excess of two-thirds the smallest inside diameter of that part of the well being tested per 100 ft. of depth.
   3. Plumbness and alignment exceeding tolerances shall be corrected, failure of correction shall be cause to reject well.

3.6 WELL PERFORMANCE TESTING

A. Wells shall be test pumped as described in the section: Well Performance Testing.

3.7 WELL ABANDONMENT

A. Wells, test wells, and temporary wells to be abandoned either temporarily or permanently shall be sealed with material and procedures required by governing authority.

B. A report shall be made to the governing authority for every well which has been abandoned or temporarily removed from service and include:
   1. Detailed description of location, construction, and geologic features.
   2. Method of sealing.

3.8 SAFETY AND RELATED MATTERS

A. Comply with all federal, state, and local rules and regulations concerning:
   1. Construction safety.
   2. Noise control.
   3. Dust and smoke control.

B. Access to Public Services
   1. Insure free access to all fire hydrants, valve boxes, manholes, curb stops, fire alarms, police call boxes.

C. Protection of Work, Public and Property
   1. Provide safe passage for local traffic, pedestrian and vehicular.
   2. Provide access to properties abutting street where well is being constructed.
   3. Provide all necessary barricades, warning lights, and signs, signals, flagmen, etc. in accordance with federal, state, and local regulations.
   4. Obtain and comply with required permits.
   5. Machinery, equipment, and hazards shall be guarded in accordance with federal, state or local regulations.
   6. Excavations and trenching shall be made in accordance with safety practices formulated and enforced by federal, state, and local regulations.
   7. Notify police or sheriff's department and fire department before blocking off street, highway, alley or public thoroughfare.

3.9 EXISTING UTILITIES AND STRUCTURES

A. When existing utilities and structures are indicated on drawing, it should not be assumed that all existing utilities and structures are shown.
   1. The location of existing utilities and structures when given are plotted on the drawings for information to the Contractor, but is not to be construed as a representation of the actual location.
   2. Contractor shall be responsible for injuries and damage to any structures, facilities, utilities, and public or private property resulting from construction and testing of wells.

3.10 PROTECTION OF ESTABLISHED PROPERTY MARKERS

A. Protect all property markers (iron pipe, concrete or wood posts, etc.) from movement from original position.

B. Cost of replacement of property markers moved during construction shall be at Contractor's expense.

3.11 CLEANING OF PROJECT SITE

A. Work Site
   1. Keep the site of the work including all private or public property involved in or adjacent to the work, free from any rubbish, surplus or waste materials deposited or which have accumulated as a result of the work.
   2. Remove all materials, tools, and equipment leaving the site of the work clean, unobstructed and ready for use.

Appendix B-2

Well Performance Testing

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes method and equipment required for test pumping wells.

1.2 QUALITY ASSURANCE

A. A chlorine residual shall be available in the well during installation of test pumping equipment.

1.3 SUBMITTALS

A. One copy of discharge and drawdown data to Owner's representative.

1.4 WELL DESIGNATION

A. Well A - Potable Well

B. Well B - Non-potable Well

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Pump and Piping
   1. Provide necessary discharge piping complete with valve for throttling.
      a. Shall be of sufficient size and length to conduct flow to discharge point.
   2. Set well pump to depth of:
      a. Well A: 165 feet
      b. Well B: 175 feet
   3. Provide internal combustion engine and gear drive or electric motor of sufficient horsepower to meet requirements.
      a. Silencers shall be required.

B. Measuring equipment to determine the flow and depth of water.
   1. Pipe orifice and manometer or water meter.
   2. Air line to bottom of test pump or an electric water level indicator.
   3. Gauge, hand pump or air compressor and check valve on air line.

C. Sample Tap
   1. Provide smooth end, downward opening tap in discharge piping at the well.

PART 3 - EXECUTION

3.1 TEST PUMPING

A. Perform test pumping after completion of cleaning.

B. Pump at a rate of Well A: 200 gpm, Well B: 400 gpm, or maximum capacity of well, whichever is less.
   1. Water level shall not be lowered below top of screen.

C. Provide drawdown and discharge readings at:
   1. One minute intervals for first five minutes.
   2. Five minute intervals for next twenty-five minutes.
   3. No more than one-half hour intervals for the balance of the test.
   4. Record on approved forms.

D. Recovery Readings
   1. Conduct for a minimum of one hour after the pump is stopped.

E. Preliminary Test Pumping
   1. Conduct for a minimum of two hours.

F. Final Test Pumping
   1. Conduct for a minimum of 12 hours.

G. Disposal of Water
   1. Point of discharge shall conform to following:
      a. Locate in an area which will prevent recharge of well.

Appendix B-3

Gravel Pack Well

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work under this section covers construction of gravel pack wells in unconsolidated formations.

1.2 QUALITY ASSURANCE

A. Contractor shall be responsible for selection of screen opening size, screen strength, and gravel pack gradation.
   1. Samples of formation for sizing shall be obtained during drilling.
   2. Provide Owner's representative with screen and gravel pack data prior to installation.

1.3 SUBMITTALS

A. Testing Results
   1. One copy of certification of gravel pack material showing gradation and percent of calcareous material.

PART 2 - PRODUCT

2.1 SCREENS

A. Screen material and fittings shall be type 304 stainless steel unless otherwise specified.

B. Screen to be welded construction and stainless steel welded.

C. Bottom plate and fittings to be of same material as screen.

D. Telescopic size screens shall be attached to casing with a Johnson Division, or equal, Fig. K packer.

E. Openings shall be slots which are continuous around circumference of screen and widen inwardly.

F. Slots shall have close spacings to provide maximum percent of open area.

G. Entrance velocity of water shall not exceed 0.1 feet per second and head loss shall be minimal.

H. Screens to be Johnson Division, or equal.

2.2 GRAVEL PACK MATERIAL

A. Material
1. Gravel pack material shall be clean with well rounded grains that are smooth and uniform.
2. Material shall be mostly acid resistant siliceous particles.
3. Calcareous material shall be limited to 5%.
4. Material shall be free from shale, anhydrite and gypsum.

B. Gradation of Material
1. Gradation of material shall be from sieve analysis curves of aquifer material.
2. The uniformity coefficient shall be less than 2.5.

C. Handling
1. Deliver and store in such a manner that material shall be kept clean and free from debris.

PART 3 - EXECUTION

3.1 WELL CONSTRUCTION

A. Outer Casing(s)
1. Install to depth as shown and extend a minimum of two feet above existing ground.
2. Additional casings of larger diameter may be used in a telescoping manner prior to installation of outer casing.
3. Casing which is driven shall be equipped with drive shoe.
4. Outer casing shall be withdrawn a minimum of five feet during grouting.

B. Intermediate (Protective) Casing
1. Install to depth of as shown and extend a minimum of two feet above existing ground.
2. Casing shall have minimum thickness as specified in section: General Provisions for Well Construction.
3. Casing shall be equipped with drive shoe if driven.
4. Depending on conditions, casing may have to be partially removed to expose screen and gravel pack.

C. Inner Casing and Screen
1. Install to depth as shown and extend a minimum of two feet above existing ground.
   a. Casing shall have minimum thickness of 0.25 inches.
2. Casing and screen shall be plumb.
3. A ½ inch steel plate shall be welded between inner and protective casings as shown.
   a. Gravel fill pipes shall be welded to plate.
   b. An opening shall be made for observation pipe.
4. Screen shall be fitted and installed on inner casing.
   a. Centering guides shall be attached to screen to maintain it concentrically within protective casing until gravel pack is in place.
   b. Actual screen length will be determined after formation samples have been analyzed.

D. Observation Pipe
1. Suspend an observation pipe in the annular opening to depth shown.
   a. Pipe to be 1¼ inch, Schedule 80 PVC.
   b. Sand point to be 3 foot long stainless steel.

E. Gravel Pack Placement and Casing Removal
1. Fill annular space between casing and screen with selected gravel pack as casing is withdrawn.
   a. Gravel shall be placed with a tremie pipe.
2. Level of gravel shall be kept at least 10 feet above the bottom of casing to prevent heaving of native formation into gravel wall.
3. Gravel shall be brought up to ground surface.

F. Grout Placement
1. Install impervious seal at bottom of annular opening as shown.
2. Commence placement of grout.
3. Maintain grout at least 10 feet above bottom of casing to prevent native formation from slumping into grout or gravel pack while withdrawing outer casing.

3.2 WELL DEVELOPMENT AND TEST PUMPING

A. Start development of well only after grout has set for 72 hours.
1. Continue development until well is free of sand.
2. Well will not be considered fully developed until sand free.
3. The installation of hexametaphosphate is part of the development.

B. Hydraulic jetting is to be the method used for development.
1. Minimum jet velocity shall be 150 feet per second with jets less than one inch from screen.
2. Jetting tool shall be slowly rotated.
3. Jetting shall be from bottom of screen upward.
   a. Tool shall be positioned at one level for a minimum of two minutes and raised a maximum of six inches between levels.
4. Water shall be removed from well at a rate in excess of rate of injection.
5. Extreme care must be practiced to avoid damage to screen.

C. Test pump in accordance with Section: "Well Performance Testing."

Appendix C

Estimated Potable Well and Non-potable Well Drawdown

GeoTrans, inc.
GROUNDWATER SPECIALISTS

1080 Holcomb Bridge Road ▪ Building 200, Suite 305 ▪ Roswell, Georgia ▪ 30076

404 ▪ 642 ▪ 1000 (Telephone) 404 ▪ 642 ▪ 8808 (FAX)

MEMORANDUM

TO: Paul Egelhoff, Foth & Van Dyke

FROM: Todd Hagemeyer, GeoTrans RTH

DATE: October 10, 1995

SUBJECT: Estimated Potable and Non-Potable Well Drawdown
GeoTrans Project No. 7702-003

Two simulations to estimate the drawdown caused by proposed site wells have been completed.

The first simulation considers the potable production well near Little Sand Lake that will pump at 68 gpm which includes 25 gpm for potable use and 43 gpm for Skunk Lake mitigation. The well will be screened in the outwash and was assigned in model layer three. Figure 1 shows the steady-state drawdown from the potable well. Maximum drawdown near the well is 3.00 feet. The two foot contour extends out a distance of approximately 100 feet from the well.

The second simulation considers the non-potable well proposed near the TMA that will pump intermittently as follows:

For 100 days at 200 gpm for 12 hours/day
For 40 days at 300 gpm for 12 hours/day

This cycle is expected to occur every three years. The model simulation used a pumping rate of 114 gpm to represent an average rate for each pumping cycle lasting 140 days. The well will be screened in the outwash and was assigned in model layer three. Figure 2 depicts the simulated transient drawdown at the end of a 140-day cycle on the TMA well. Maximum drawdown near the well is 11.8 feet. The two foot contour extends out a distance of approximately 1200 feet from the well. The drawdown in Figure 2 represents the maximum drawdown that would occur at the end of each cycle, after which water levels will fully recover before the beginning of the next cycle.

A:\EGELHOFF.WP6

Figure 1. Steady State Drawdown from 68 gpm Potable Well

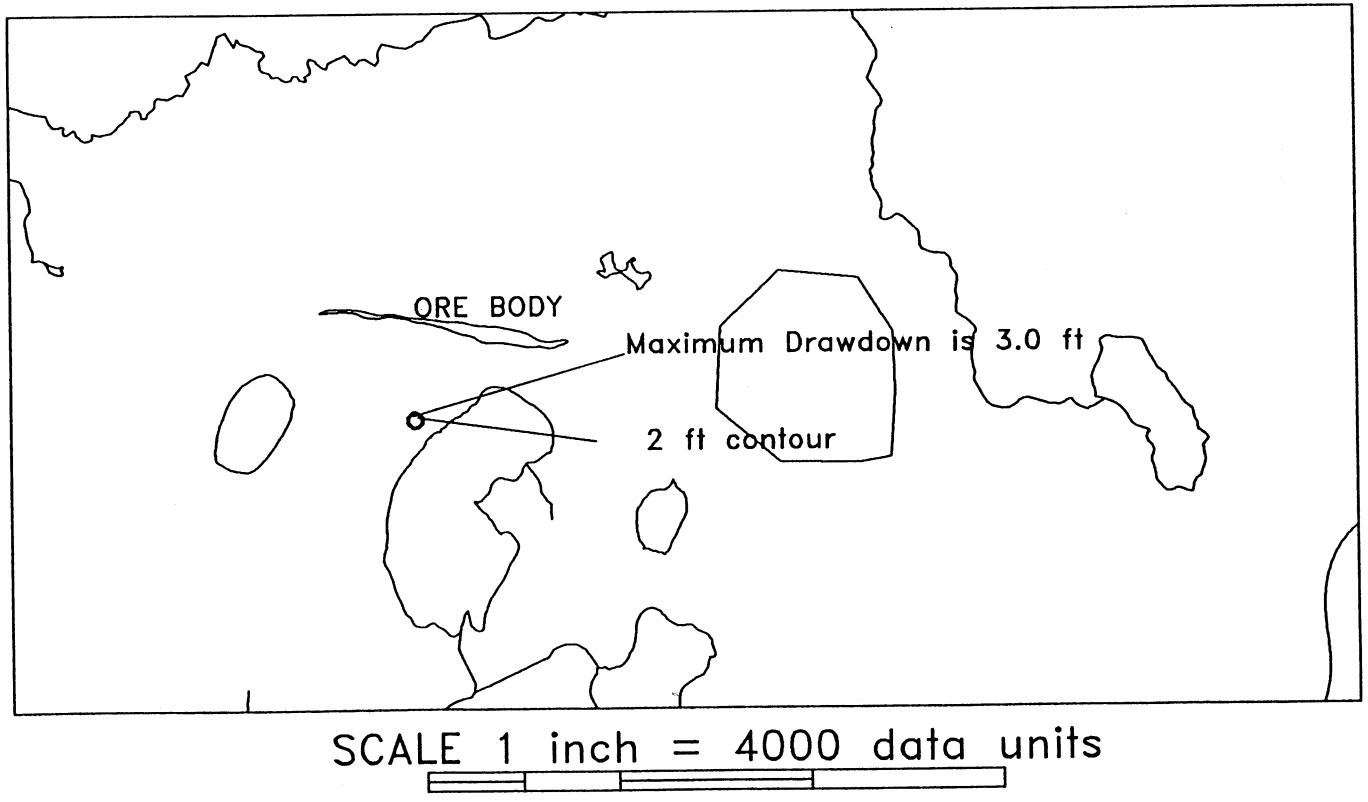


Figure 2. Drawdown From 114 gpm Non-potable Well At End Of 140 Days